JSC-08414

SKYLAB MISSION REPORT
FIRST VISIT

(NASA-TM-X-69452) SKYLAB MISSION REPORT, FIRST VISIT (NASA)

N74-70051

Unclas

00/99 20489

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

250

JSC-08414

SKYLAB MISSION REPORT
FIRST VISIT

PREPARED BY

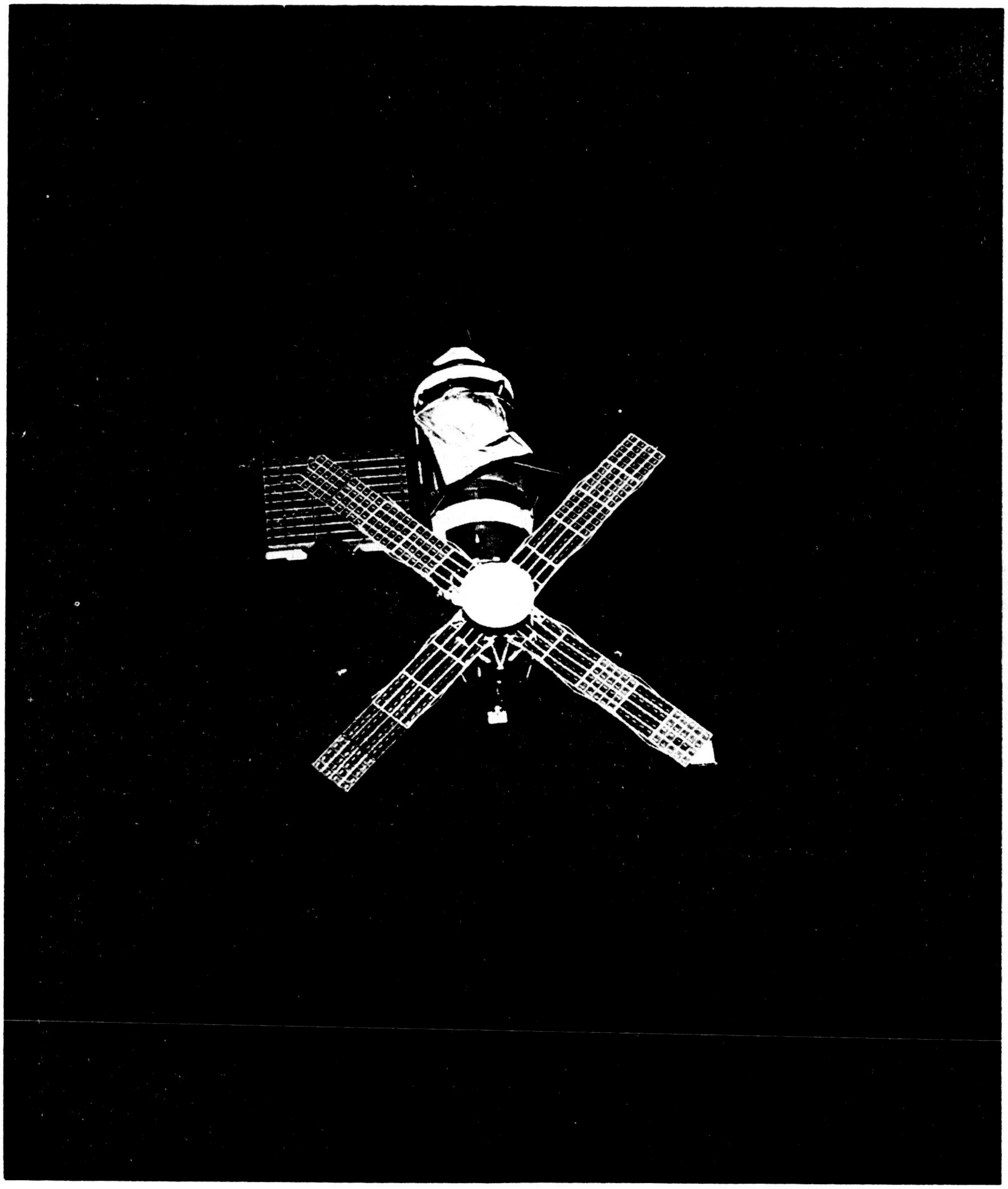
Mission Evaluation Team

APPROVED BY

Kenneth S. Kleinknecht

Kenneth S. Kleinknecht
Manager, Skylab Program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS
August 1973



Saturn Workshop

FOREWORD

The Skylab Program was established to determine man's ability to live and work in space for extended periods; to determine and evaluate man's physiological responses and aptitudes in the space environment and his postflight adaptation to the terrestrial environment; to extend the science of solar astronomy beyond the limits of earth-based observations; to develop improved techniques for surveying earth resources from space; and to expand the knowledge in a variety of other scientific and technological regimes.

The program activity was planned for four distinct phases of operation:

a. The placement of a Saturn Workshop into earth orbit;

b. The first visit, intended for a period of 28 days;

c. The second visit, intended for a period of 56 days; and

d. The third visit, also intended for a period of 56 days.

This report constitutes the Johnson Space Center's evaluation of the first visit. The report is presented in two parts, and contains the information available 30 days after the completion of the first manned visit.

A Unified Skylab Mission Evaluation Report will be published by NASA Headquarters after completion of the final visit.

TABLE OF CONTENTS

1a

PART I

SATURN WORKSHOP

PART I

1.0 INTRODUCTION

Part I of the First Visit Report contains a resume of the launch and activation of the unmanned Saturn Workshop. This section presents operational and engineering aspects of the Saturn Workshop performance from lift-off to the docking of the first visit spacecraft. A complete Saturn Workshop evaluation will be presented in the Marshall Space Flight Center's Saturn Workshop Report which will be incorporated as Volume III of the Skylab Mission Evaluation Report to be published by NASA Headquarters. A vehicle description is contained in reference 1.

The International System of Units (SI) is used throughout. Unless otherwise specified, time is expressed as Greenwich mean time (G.m.t.) in hours, minutes, and seconds, or in hours and minutes.

2.0 RESUME OF SATURN WORKSHOP OPERATIONS

The unmanned Saturn Workshop was launched at 17:30:00 G.m.t. (1:30 p.m. e.d.t.) on May 14, 1973, from Launch Complex 39A at the Kennedy Space Center, Florida. The space vehicle consisted of the Saturn Workshop payload (fig. 2-1) and the first and second stages (S-IC and S-II) of a Saturn V launch vehicle.

An unexpected telemetry indication of meteoroid shield deployment and solar array wing 2 beam fairing separation was received 1 minute and 3 seconds after lift-off. However, all other systems of the Saturn Workshop appeared normal and the Saturn Workshop was inserted into a near-circular earth orbit of approximately 435 kilometers altitude.

The payload shroud was jettisoned and the Apollo Telescope Mount and its solar array were deployed as planned during the first orbit. Deployment of the Orbital Workshop solar array and the meteoroid shield were not successful. Evaluation of the available data indicated that the following sequence of events and failures occurred.

Time from lift-off, hr:min:sec	Event
0:01:02.9	Meteoroid shield tension strap 2 separated.
0:01:03	Meteoroid shield tension strap 1 and 3 separated.
0:01:03	Solar array system wing 2 beam fairing separated.
0:01:30	Meteoroid shield temperatures went off-scale.
0:01:30	Partial deployment of Meteoroid shield was indicated.
0:10:00	Thermal measurements on wing 2 solar array panels ranged from 345° K to 389° K, compared to the expected temperature of about 300° K. Wing 1 temperatures remained normal.
0:55:59.9	Wing 1 beam fairing separated.

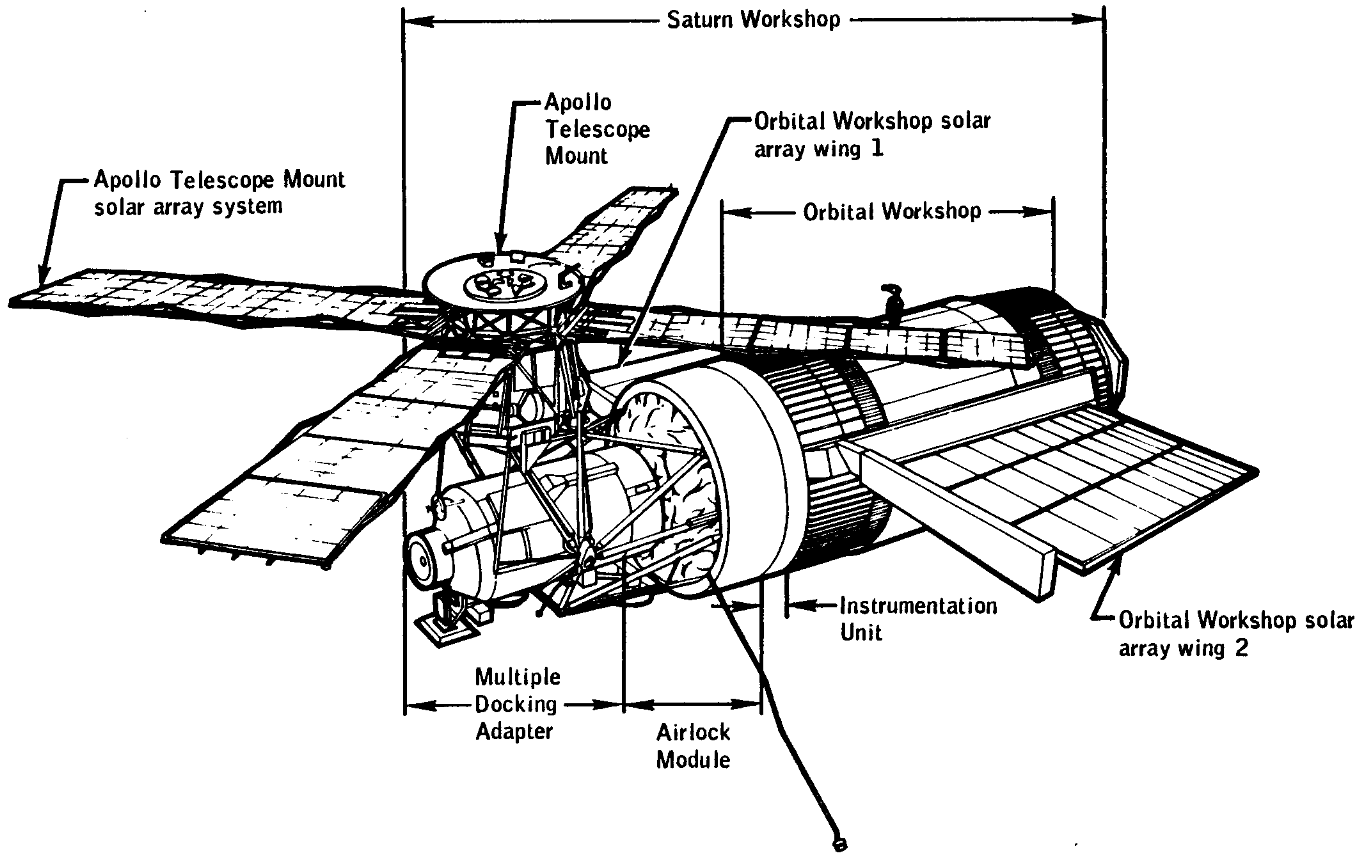


Figure 2-1.- Saturn Workshop.

The solar array wing was released; however, there were indications that the wing had not fully deployed. Wing 2 was inoperative or encountered structural failure. Temperature excursions in the Orbital Workshop showed that the meteoroid shield was not affecting the temperatures as intended. The remainder of the planned Orbital Workshop system activation and deployment functions occurred as scheduled with transfer of attitude control from the Instrument Unit to the Saturn Workshop approximately 4 1/2 hours after lift-off.

The Saturn Workshop was maneuvered into a solar inertial attitude with the plane of the solar arrays normal to the sun for maximum electric power generation. The Orbital Workshop area temperature then rose above operating limits. The Saturn Workshop was subsequently pitched up toward the sun at 13 hours into the flight to reduce the solar incidence angle on the Orbital Workshop area. This attitude further reduced the power generation capability which had already been severely limited by the loss of the Workshop solar array wing 2 and the failure of wing 1 to deploy. A continuing adjustment of attitude was necessary to keep the power and temperature within acceptable limits. Constraints to maintain adequate heat in other critical areas of the Saturn Workshop and to optimize the operation of the attitude control system in an off-nominal mode added further complications. This delicate balance continued for approximately 10 days.

The electrical power available from the Apollo Telescope Mount solar array was further reduced by the requirement to cycle certain power regulator modules on and off to prevent the overheating caused by unplanned vehicle attitudes. Although considerably below the total design capability of approximately 8500 watts, the power was sufficient for the critical loads. Many components and systems were turned off or were cycled as required to remain within the power generation capability.

The high internal temperatures that were reached in the Workshop can cause outgassing of some materials which could have been hazardous to the crew. Therefore, prior to the crew arrival, the habitation area was depressurized and repressurized four times with nitrogen to purge the outgassing products. The final repressurization was with the proper oxygen/nitrogen mixture for the crew.

Maneuvering into and out of the various thermal control attitudes and maintaining attitude hold and control during several docking attempts caused a much larger usage of the Orbital Workshop thruster propellant than predicted. Sufficient propellant remained, however, for the three manned missions that were planned.

PART II

FIRST VISIT

PART II

1.0 INTRODUCTION

Part II of the First Visit Report contains an evaluation of the first visit payload systems; the performance of experiment hardware under Johnson Space Center management; the crew's evaluation of the visit; and other visit-related items of interest, such as medical aspects and hardware anomalies.

The command and service module consisted of basic hardware developed for the Apollo program. The vehicle description is contained in reference 1. This report provides information on the operational and engineering aspects of the first visit. Scientific results will be reported in accordance with reference 2. Launch vehicle performance will be reported in Volume III of the Unified Skylab Mission Evaluation Report.

The International System of Units (SI) is used throughout. Unless otherwise specified, time is expressed as Greenwich mean time (G.m.t.) in hours, minutes, and seconds or in hours and minutes.

2.0 SUMMARY

The first visit space vehicle was launched at 13:00:00 G.m.t. (9:00 a.m. e.d.t.) on May 25, 1973 (first visit day), from Launch Complex 39B at the Kennedy Space Center, Florida. The vehicle was manned by Captain Charles Conrad, Jr., Commander; Commander Joseph P. Kerwin, Science Pilot; and Commander Paul J. Weitz, Pilot.

The originally scheduled launch time was 10 days earlier, on May 15, 1973; however, thermal problems encountered with the Orbital Workshop necessitated the rapid design and construction of supplemental hardware to be transported by the first manned vehicle. The intervening period was also used for intensive crew training in new and modified procedures and for restowing the command module with items which were considered to have been damaged by the elevated temperatures.

The space vehicle, consisting of a modified Apollo command and service module payload and a Saturn IB launch vehicle, was inserted into earth orbit approximately 10 minutes after lift-off. The orbit achieved was 357 by 156 kilometers and, during a 6 hour period following insertion, four maneuvers were used to place the command and service module into a 424 by 415 kilometer orbit for rendezvous with the Saturn Workshop. Normal rendezvous sequencing led to station keeping during the fifth revolution followed by a flyaround inspection of the damage to the Orbital Workshop.

The crew provided a verbal description of the damage in conjunction with 15 minutes of television coverage. Solar array system wing (beam) 2 was completely missing. Solar array system wing (beam) 1 was slightly deployed and was restrained by a fragment of the meteoroid shield. Large sections of the meteoroid shield were missing. Following the flyaround inspection, the command and service module was soft docked with the Saturn Workshop to plan the next activities.

A command and service module extravehicular activity was initiated at 23:52:15 G.m.t. on visit day 1, to attempt the deployment of the beam 1 solar array, but was unsuccessful. The crew's frustration was compounded when eight attempts were required to achieve docking with the Saturn Workshop. The first manned day terminated after a crew work period of 22 hours.

The second manned day was focused toward entry into the Saturn Workshop. The crew removed and inspected the docking probe and drogue, and then entered the Multiple Docking Adapter to activate the Airlock Module and the Multiple Docking Adapter systems. The Orbital Workshop atmosphere was habitable, though hot, and the crew found no particular discomfort in working in the environment for 10 to 15 minute intervals.

A Skylab parasol, designed to thermally protect the area exposed to the sun by the missing meteoroid shield, was deployed through the solar scientific airlock about 5 hours into the second workday. As a result, the internal Orbital Workshop temperatures began decreasing. The command module was then unstowed and all systems were deactivated except for those which were required to support the Workshop and to maintain minimum command and service module requirements.

The crew established the Workshop manning routine and, for the next 11 days, performed scientific and medical experiments under a reduced power profile. During a 3 1/2 hour extravehicular activity on mission day 13, the Commander and Science Pilot freed and deployed beam 1 and its solar array. Adequate power was then available in the Saturn Workshop at return to near normal activities.

Another extravehicular activity was performed on the 26th manned day to replace Apollo Telescope Mount film cassettes and obtain thermal coating samples. In addition, the Commander performed inflight repairs on the Apollo Telescope Mount instruments and also succeeded in reactivating a malfunctioning charger battery regulator module. This was the final day of significant scientific and experiment activity. The remaining time was devoted to Workshop housekeeping and stowage of the command module in preparation for termination of the first visit.

The command module was reactivated on the last visit day and, after donning suits, the crew performed the final Saturn Workshop closeout, entered the command module, and undocked. A flyaround of the Saturn Workshop was performed to inspect and photograph it.

The command module separated from the vicinity of the Saturn Workshop at 09:40:00 G.m.t. on visit day 29, and all entry events were normal. The command module landed in the Pacific Ocean approximately 1300 kilometers southwest of San Diego, California. The time of landing was 13:49:49 G.m.t. on visit day 29, and the spacecraft was within visual range of the recovery ship, the USS Ticonderoga. The command module remained in a stable 1 attitude (upright) and the first visit terminated when the spacecraft and crew were aboard the recovery ship about 40 minutes after landing. The total flight time of the first visit was 672 hours 49 minutes and 49 seconds.

3.0 SKYLAB PARASOL

The Skylab parasol (fig. 3-1) was launched with the first visit spacecraft. The parasol provided thermal shielding for the area of the Orbital Workshop which was exposed to the sun because of the missing meteoroid shield. The parasol concept, design, development, construction and delivery to the Kennedy Space Center were accomplished within 7 days by the Johnson Space Center. Two other thermal protection devices were also devised and delivered during this same time period. One was a sail, produced by the Johnson Space Center, and designed to be deployed by an extravehicular crewman standing in the command module hatch while the spacecraft was being flown in close proximity to the Orbital Workshop. The other, called a twin boom sunshade, produced by the Marshall Space Flight Center, was designed to be deployed by extravehicular crewmen from the Apollo Telescope Mount station.

The parasol provided a means of deploying a thermal protective device which was simple, and could be accomplished from within the Orbital Workshop in a shirt-sleeve environment. The system is also capable of being jettisoned.

Figure 3-2 shows the packed parasol. Figure 3-3 shows the deployed parasol. The parasol concept made use of a spare experiment T027 canister which was designed to interface with the solar scientific air lock. The seal design used in the back plate of the experiment canister was incorporated into a new back plate required for the parasol. This allowed the use of deployment rods which were of the same type used for experiment deployment, and also allowed use of the experiment T027 photometer ejection rod, if jettisoning becomes necessary.

Major components of the parasol, other than the modified canister, were a 6.7 by 7.3 meter aluminized Mylar/nylon laminate canopy that was partially opaque to solar thermal energy, a canopy mast, a mast hub with deployment springs, four telescoping deployment rods, seven extension rods, and the experiment T027 canister support tripod.

The canopy is a laminate of orange rip-stop nylon bonded to 0.05 mm aluminized Mylar (fig. 3-4). The hem around the periphery of the canopy has 2.54 centimeter nylon tape and 0.635 centimeter diameter PBI line sewn into it. The PBI line provided the means of attachment to the deployment rod ends. The nylon side of the canopy is toward the sun and provides an α/ε of 0.44 with an α of 0.37 and an ε of 0.84. Long term exposure to sunlight is expected to cause the α/ε to change to about 0.7. An α/ε of less than 1.0 will provide adequate thermal protection. The back side of the aluminized surface provide a low emmittance which reduces thermal radiation between the canopy and the Orbital Workshop.

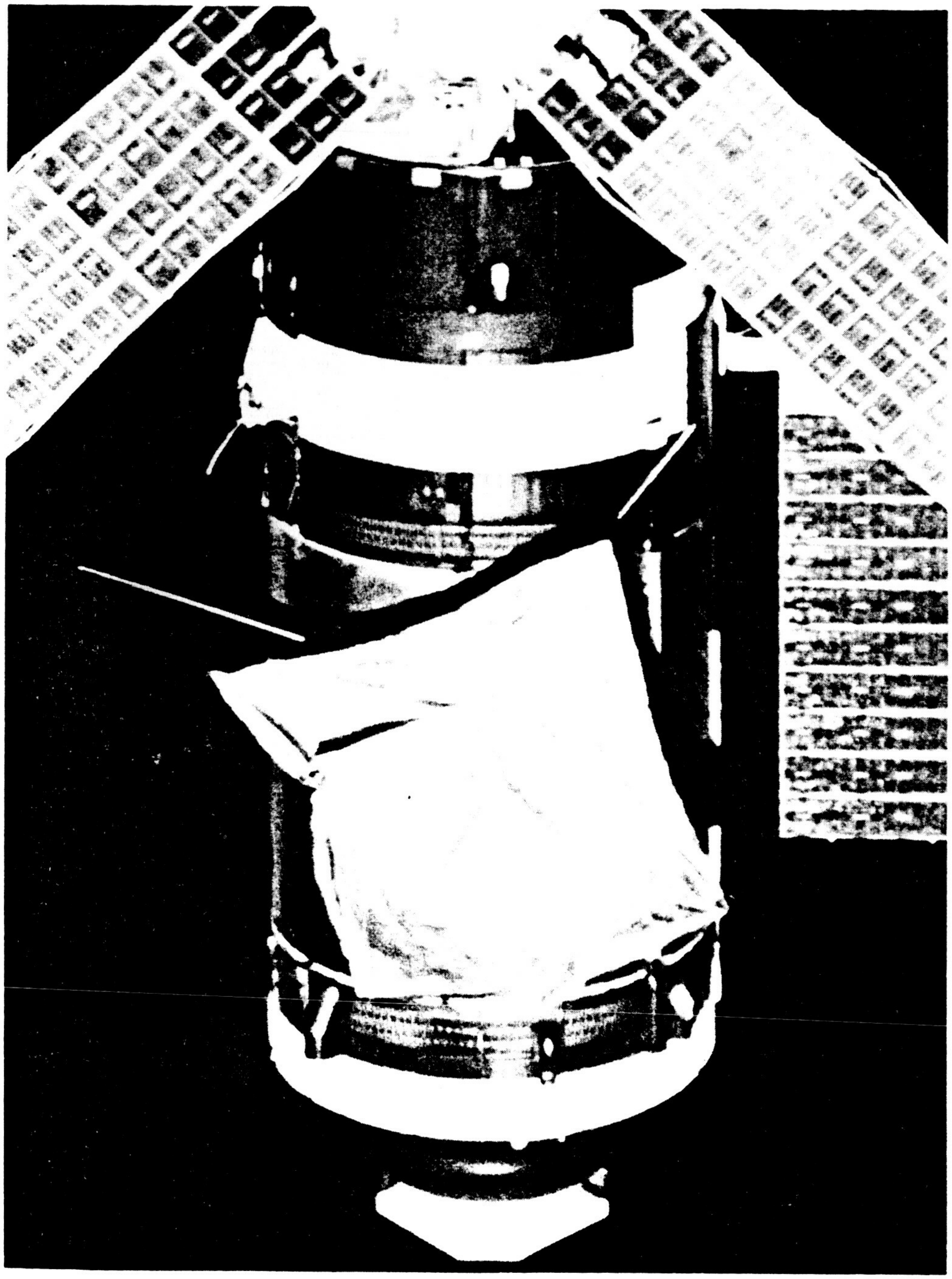


Figure 3-1.- First Skylab parasol as deployed.

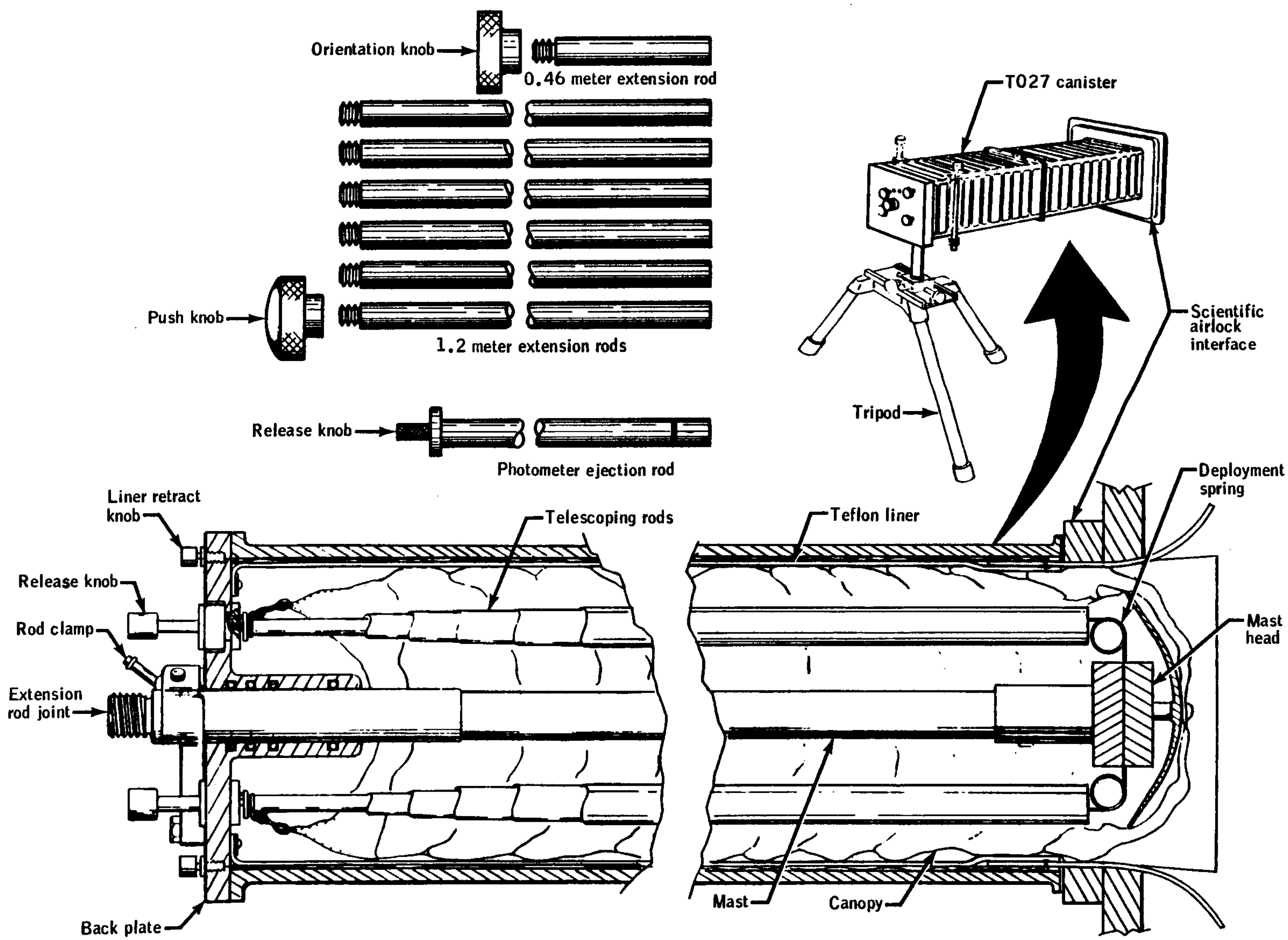


Figure 3-2.- Parasol packed configuration.

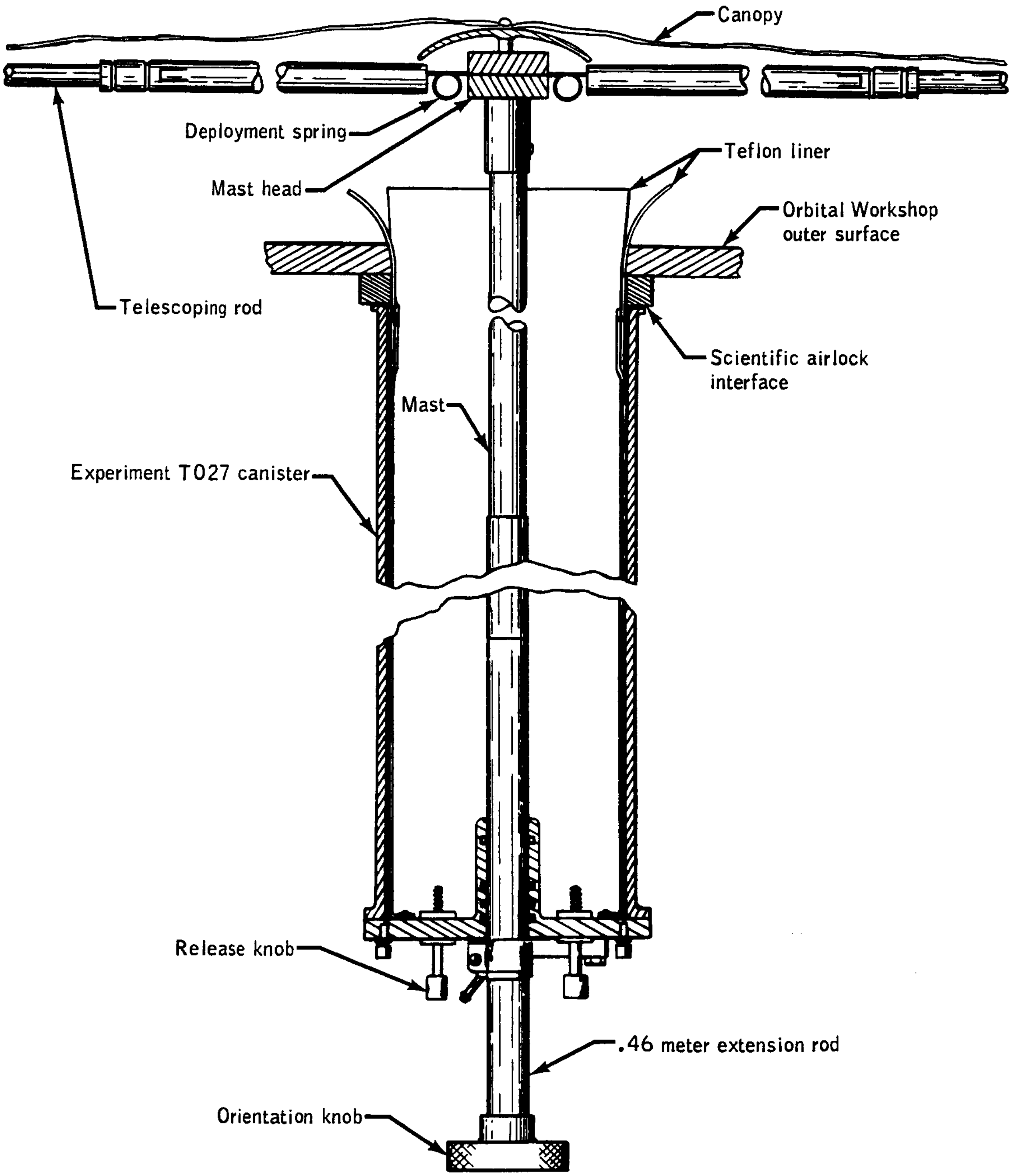


Figure 3-3.- Parasol deployed configuration.

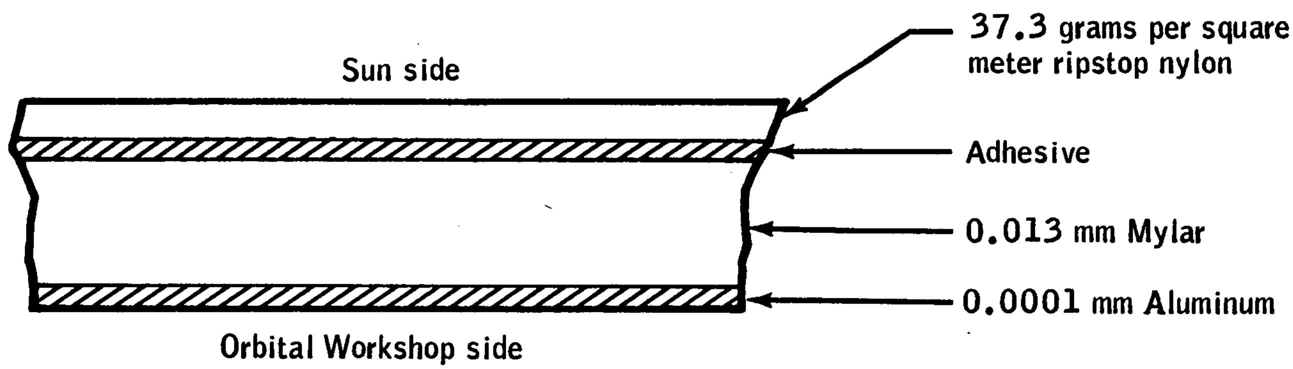


Figure 3-4.- Parasol canopy material connection.

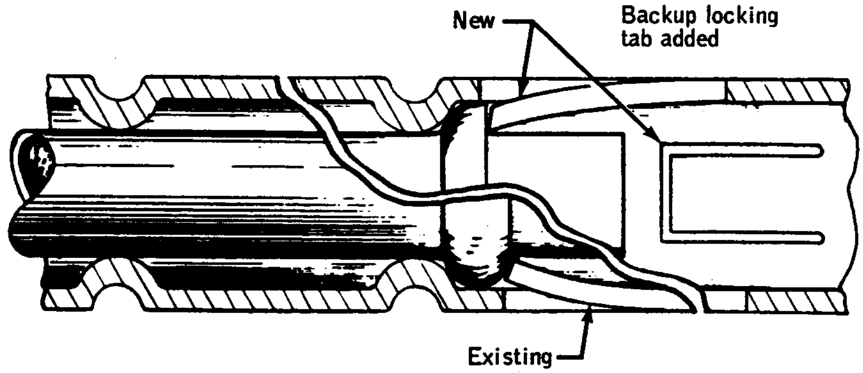
The back plate of the canister contained provisions for extending the mast and extension rods, and disconnecting devices for the telescoping deployment rod tip retainers. The plate also contained O-ring seals to maintain the Orbital Workshop pressure integrity. A friction brake prevented inadvertent turning or overextension of the canopy.

Deployment was accomplished through the solar scientific airlock by attaching the extension rods to the mast and pushing the rod assembly outward. As the mast hub was extended to 4.9 meters above the opening of the airlock, the telescoping deployment rods became fully extended and locked, and the tip retainers for the telescoping rods were released. The mast hub was then extended to 6.4 meters above the outer surface of the Orbital Workshop, allowing the rod tips to swing free of the solar scientific airlock opening and deploy the canopy. The parasol was then retracted to its final position a few centimeters above the Orbital Workshop outer surface. During the retraction process, the long extension rods were removed and the short extension rod was left in place.

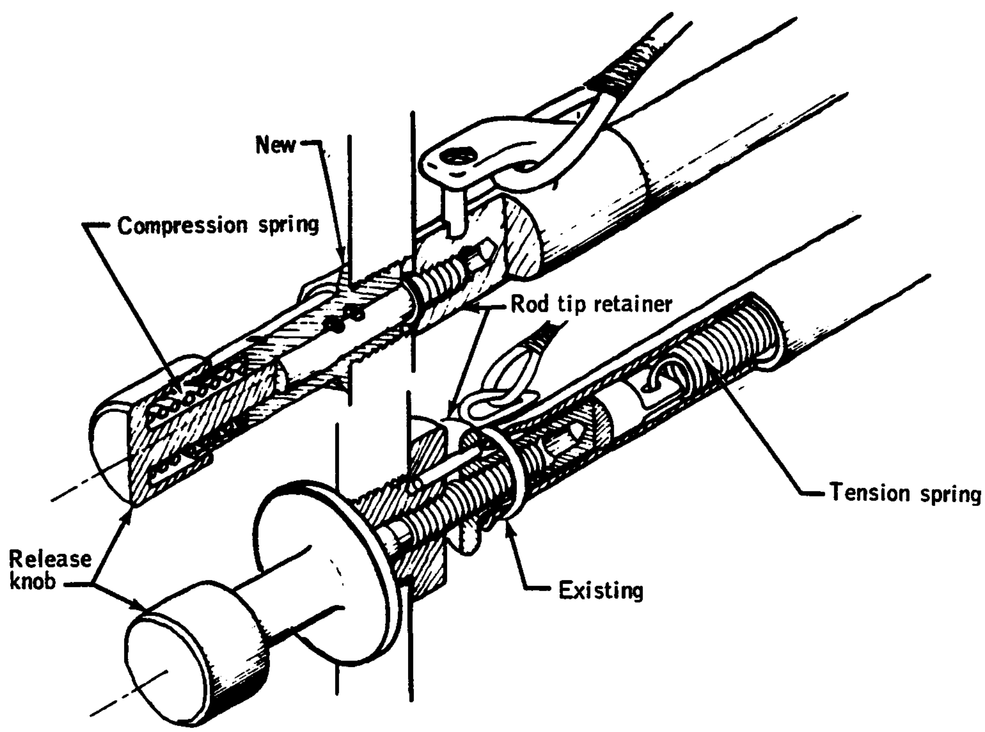
As presently deployed over the Orbital Workshop, all telescoping rods are deployed to the horizontal plane, but the canopy is not fully spread. Photographs taken during the flyaround inspection indicate that one section of three of the four telescoping deployment rods was unlocked and that only one of the 4 rods was completely extended. This results in a reduction of about 25 percent in the planned area of coverage.

The telescoping rod tip retainers are attached to the rods by springs which are extended several centimeters in locking the rod sections together (fig. 3-5). Release of these retainers with the spring fully stretched imparts a shock force on the rod locks. The design is such that shock loading can trip the lock. The design of the rod locks and retainers on the new parasol has been changed to provide a more positive lock and to eliminate the shock force (fig. 3-5).

Orbital Workshop temperatures started dropping immediately upon parasol deployment. The initial temperature drop for the outer wall exceeded 36° K per hour. Temperatures within the Orbital Workshop, though dropping at a much slower rate, were below 311° K within a day of deployment. The inside temperature continued a steady decline until stabilization was reached somewhat below 297° K (fig. 3-6). As a result of the crew's observations during the final extravehicular activity, the canopy was repositioned 0.26 of a radian to provide better thermal control. The overall temperature effects from this repositioning were negligible because of the reduced coverage. The effect was to increase the temperature in the sleep area. The parasol was therefore rotated towards its original position. Note that at the end of the first visit the temperatures increased because of the increase of daytime exposure for the orbital plane at that time of the year.



(a) Telescoping rod lock.



(b) Telescoping rod tip retainer and release device.

Figure 3-5.- Telescoping rod lock and tip design.

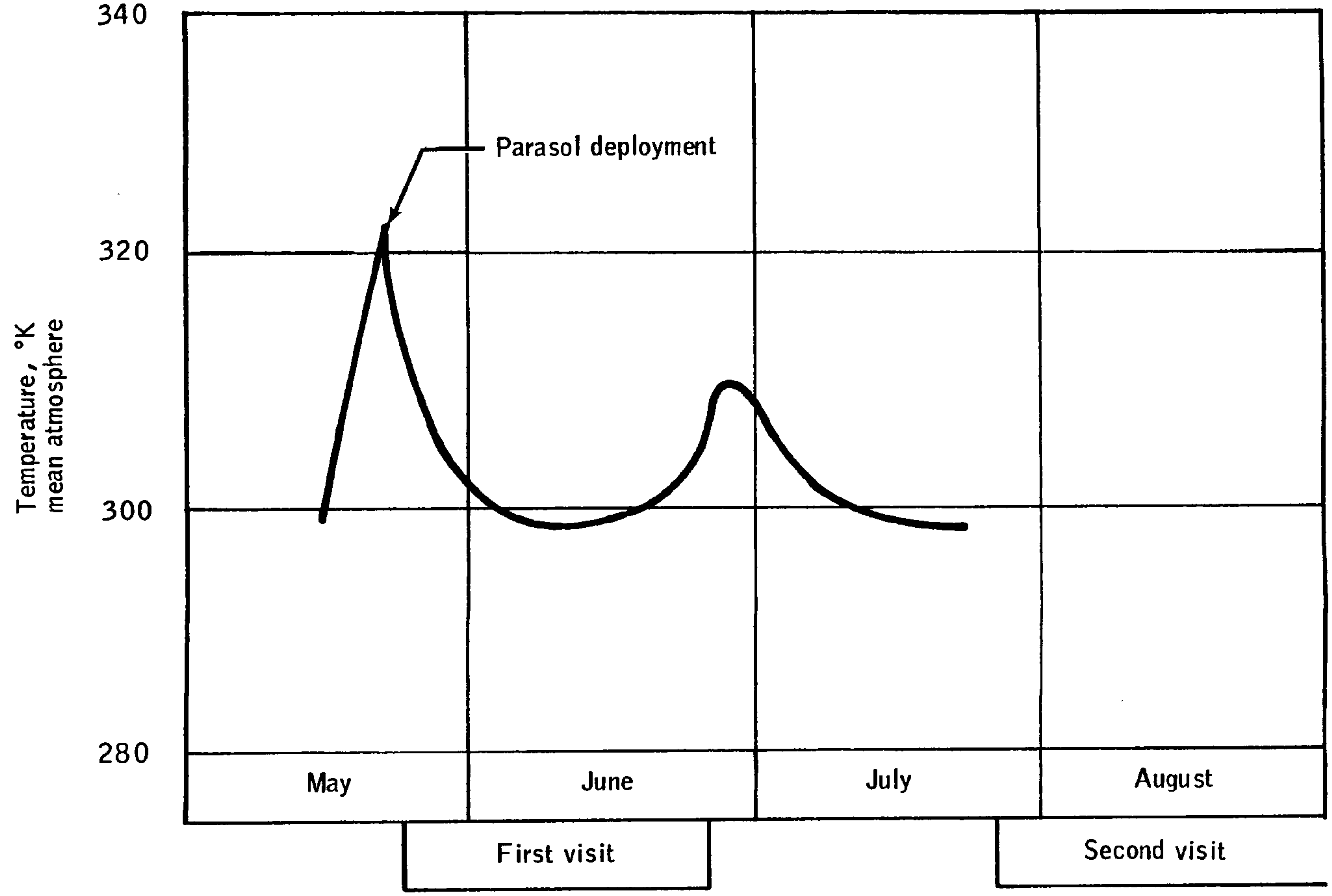


Figure 3-6.- Parasol effect on cabin temperature.

Ground tests of the canopy material with simulated sunlight indicated that the nylon would lose strength with exposure to sunlight. However, observations made by the crew during the flyaround inspection and comparison of virgin nylon with nylon exposed to 500 hours of equivalent sunlight (end of first visit) indicate that the ground simulation does not represent the actual exposure conditions. The material is not being affected as tests indicate as gaged by the change in color. The color must change before the strength changes since the dye protects the nylon from ultraviolet rays.

The virgin nylon is bright orange in color. The sample exposed to simulated sunlight for 500 hours changed to a dull gold color. The crew's comment upon examination of these two samples was that the parasol looks like the virgin sample in color, except that it had less sheen.

Figure 3-7 is the effect of ground simulation of sunlight on strength and elongation of the orange rip stop nylon material. The 50 percent remaining strength (4465 gram/cm) after 2600 equivalent sun hours exposure (end of second visit) is more than adequate to satisfy structural requirements (892 gram/cm). The 50 percent remaining elongation (19 percent) is more than adequate to satisfy structural requirements (10 percent). Examination of samples yield no evidence that any loose nylon particles are being created which could cause contamination of experiments. The adherance of any surface "crust" (weak nylon) is still quite good after 2600 hours and appears to have stabilized.

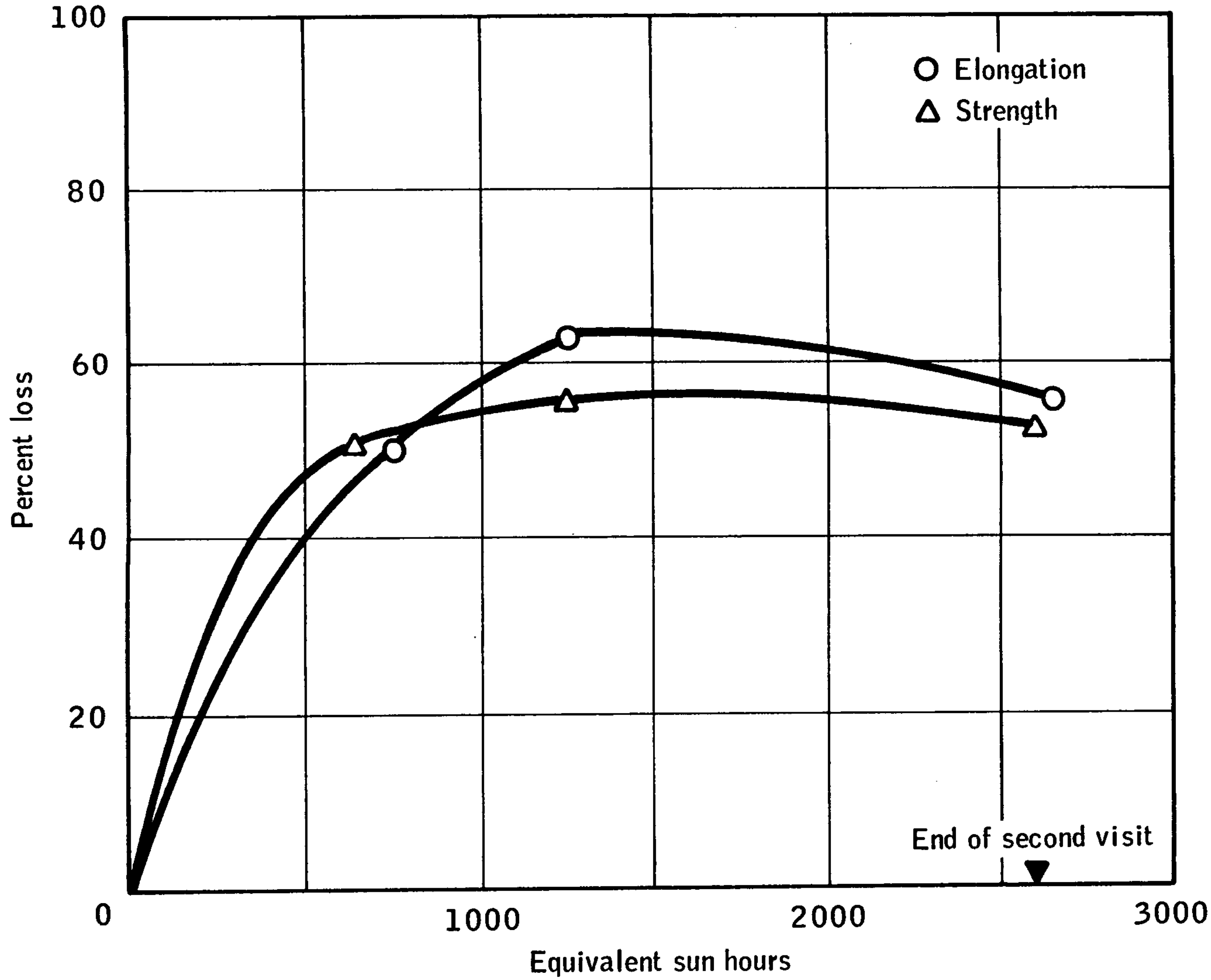


Figure 3-7.- Effect of ground simulation of sunlight on strength and elongation of orange rip-stop nylon.

4.0 SCIENCE

This section discusses only those experiments under the management of the Johnson Space Center. Many additional experiments under the management of the Marshall Space Flight Center were conducted and are discussed in a separate report.

4.1 SOLAR PHYSICS AND ASTROPHYSICS

Three experiments were planned for the first visit in the solar physics and astrophysics areas. These were experiment S019 (Ultraviolet Stellar Astronomy), experiment S020 (Ultraviolet X-Ray Solar Photography), and experiment S149 (Particle Collection). All of these experiments were to be performed through the scientific airlocks. Experiment S019 was to be conducted through the anti-solar airlock, experiment S020 through the solar airlock, and experiment S149 through both airlocks. The solar airlock was used during the entire mission by the Skylab parasol; consequently, this eliminated the performance of experiment S020 and limited the performance of experiment S149. Experiment S019 was not directly affected by the loss of the solar airlock, but changes in the flight plan indirectly resulted in completion of only a portion of the originally planned passes.

4.1.1 Experiment S019 - Ultraviolet Stellar Astronomy

Data were collected on three and one-half passes for the S019 experiment. One additional pass was used for calibration and one additional data taking pass was used for student experiment ED23 (Ultraviolet from Quasars).

The spectral data appear to be of excellent quality. The data for the prism off fields may be degraded because of large spacecraft attitude rates during the observations.

During the initial activation of the S019 experiment, the tilt mechanism was found jammed. The jamming was isolated to interference between the tilt display gear clamp screw and the aluminum cover. A repair procedure teleprinted from the ground corrected the problem and restored the experiment to normal operation. Details of this anomaly are given in section 17.2.3.

Two problems occurred in the widening of the spectra. First, the widening mechanism operates faster than anticipated by about 20 percent.

That is, 270 second exposures are accomplished in about 220 seconds. This results in a loss of about 0.2 in limiting magnitude and is of minor significance. No adjustments are possible on the flight hardware. The second problem is irregularity of widening. This may result from external disturbances. The second visit crew has been advised not to touch the spectrograph during exposures. Likewise, it has been emphasized that crew motion should be kept to a mininum during exposures. An error in operating procedures during the first prism on pass prevented exposure. However, confirmation of experiment pointing, which was the primary objective of this pass, was accomplished.

The two no prism passes were degraded by spacecraft motion. The motion amounted to about 0.026 radian per hour. This motion was probably caused by a trim maneuver shortly before the S019 passes.

During postflight testing, a leak was found in the film canister around the reticle seal of the eyepiece. The leak and the exposure to high temperatures contributed to background fog. However, no loss of data resulted from this condition.

Ninety second exposures were made during bright moonlight conditions. No significant fogging from the moonlight was observed. Consequently, moonlight constraints will no longer be observed. Table 4-I gives a summary of the results of the first visit.

4.1.2 Experiment S020 - Ultraviolet X-Ray Solar Photography

The experiment was launched in the Orbital Workshop. However, it could not be performed because the Skylab parasol was deployed through the solar scientific airlock. Modifications to this experiment are being planned to permit its performance on a subsequent visit to the Workshop.

4.1.3 Experiment S149 - Particle Collection

Experiment S149 was installed in the anti-solar scientific airlock and operated for the first time on visit day 27. Solar side data were not obtained because of the Skylab parasol installation. The unit was operated for one complete cycle to verify all systems were functioning properly.

After crew departure, the experiment was deployed for data collection until docking on the second manned visit. Deployment and retraction are ground commanded. Deployment was normal.

TABLE 4-I.- SUMMARY OF S019 SCIENTIFIC RESULTS

Total exposures	44
Total fields observed (prism on)	11
Fields spoiled by light fog	3
Total frames exposed (prism on)	15
Frames fogged (hatch left open)	3
Stars observed down to 2500 angstroms	127
Stars observed down to 2000 angstroms	67
Stars observed down to 1500 angstroms	21
Spectra with lines in 1300 to 2000 angstrom region	14
Spectra with lines in 2000 to 2800 angstrom region	21
Fields observed (prism off)	15
Frames exposed (prism off)	29
Focus	Very good
Resolution	2 angstroms at 1400 angstroms
Limiting magnitude	5.8 magnitude B5 star to 1500 angstroms (in agreement with prediction)
Fog level - unexposed film	0.08 densitometric units
Fog rise above lab film base fog	0.05 densitometric units
Fog due to contamination introduced by canister leak	0.15 to 0.27 densitometric units

4.2 MEDICAL EXPERIMENTS

Medical experimentation comprises a major portion of the Skylab program. The experiments for the first visit were performed as shown in table I of section 14. Selected data from the experiments were plotted on trend charts to assist with crew health monitoring.

The extreme thermal environment encountered during the early phases of the first visit caused several problems with biomedical equipment stowed onboard the Orbital Workshop. The failures and/or anomalous conditions which occurred as a result of exposure to temperatures ranging from 322° K to an estimated 331° K in the stowage area are discussed in conjunction with the experiments affected.

Although the preliminary medical data thus far have pointed out the need for specific protocol and equipment modifications, none of the changes noted in the crewmembers during flight and subsequent to flight were felt to represent any unmanageable health or operational problems.

4.2.1 Experiment M071 - Mineral Balance

The foods eaten during the 31 day preflight period, the 28 day inflight period, and a 17 day postflight period were based on individual crew preference and selection. A complete record of the exact intake of all nutrients was kept for the whole of this time. The volume and chemical constituents of the water used during this time were also monitored.

All urine and feces during the 31 day preflight period were analyzed. Blood samples were obtained for the analysis of selected constituents. All the feces were dried and returned to the ground for analysis. The urine specimens were sampled and the frozen samples were returned to the ground for analysis. Urine and feces collection continued for 17 days after the flight.

Inflight caloric intakes were 200 to 300 kilocalories less than preflight baseline values, but close to the anticipated levels. The average weight loss was 5.5 percent of total body weight. The disproportionate measured loss of leg volume and total body stereophotogrammetry suggests that muscular atrophy is responsible for some of the weight loss.

Preliminary examination suggests that calcium, phosphorus, nitrogen, and, possibly, also potassium were lost from the body by urinary excretion at about the same rate that has been seen in bedrest subjects.

4.2.2 Experiment M073 - Bioassay of Body Fluids

Experiment M073 evaluates endocrinological adaptation in the space flight environment.

A slight increase in potassium excretion with relatively constant sodium excretion was observed in flight. Aldosterone was elevated and total body exchangeable potassium was decreased (6 to 8 percent) in all crewmen. The serum electrolytes show slight decreases in potassium from preflight control levels. No inflight diuresis was observed. Cortisol was significantly increased.

Postflight tests of renal function showed no gross change. Likewise, the antidiuresis hormone, aldosterone, and norepinephrine have been significantly elevated. Total body exchangeable potassium was still decreased 14 days after recovery. The changes noted were not medically significant.

4.2.3 Experiments M074/M172 - Specimen and Body Mass Measurement

Experiment M074, the Specimen Mass Measurement Device measures masses up to 1 kilogram, usually food residues and fecal specimens. Experiment M172, the Body Mass Measurement Device, measures masses up to 100 kilograms, specifically crew body mass. Only one can of food residue needed weighing during the first visit to update the daily diet information of Experiments M171/73. Fecal masses, however, were weighed daily, and the data retained for postflight analysis. Daily body weight measurements of each crewman were accomplished following sleep and the first urination, and required approximately 5 minutes per crewman per day.

The electronics module of the waste management compartment specimen mass measurement device failed early in the mission. Details are provided in section 17.2.1. A backup electronics module is being carried on the second visit spacecraft.

Data obtained indicates that adequate calibration and performance accuracy was achieved to satisfy the medical operational objectives and to support experiments M171/73 requirements. Excessive crew time was required in calibrating the experiment M172 body mass measuring device because of an unstable calibration configuration. This instability resulted from off loading of the experiment S020 film magazine stowage container from the first visit spacecraft. The experiment S020 film magazine is one of the flight items used as a calibration mass for the experiment M172 device. All calibration masses used on experiment M172 must be rigidly restrained to obtain absolute accuracy. Pieces of adhesive tape of unknown weight were used to stabilize the calibration masses and resulted in a very small overall reduction in the accuracy of the weights obtained in flight. This inaccuracy voided the achievement of the experiment M172 objective of determining the absolute accuracy capability of this type of device. The amount of error involved is probably less than 5 grams.

4.2.4 Experiment M078 - Bone Mineral Densitometry

The body tends to react to weightlessness by losing bone minerals, especially in its weight-supporting bones. Measurements of bone mineral content for the first visit were made by utilizing a gamma radiation source.

Evaluation of the recovery day data did not show a significant loss of bone mineral during the 28 days of weightlessness.

4.2.5 Experiment M092 - Lower Body Negative Pressure

Experiment M092 assesses orthostatic tolerance by measuring cardiovascular responses to lower body negative pressure. The following increasing negative pressures are applied in a time sequence: 0.11, 0.22, 0.40, 0.53 and 0.67 newtons per square centimeter.

Experiment M092 was performed on each crewman as shown in table I in section 14. All runs were according to specified limits except for a reduced level of differential pressure on the Science Pilot and Pilot during the latter phases of operation. Experiment hardware performed normally. One 13 minute period of data is unusable because of a procedural error.

Losses in tolerance to lower body negative pressure stress during flight varied among the crewmen both in rate and magnitude of change. Initially, a rapid decline in the resting calf size occurred and, thereafter, a steady, but slower, decline continued. The percent of increase in leg volume during lower body negative pressure application was much larger in flight than in either preflight or postflight tests. This excessive increase appeared to diminish in the latter part of the visit, but still remained high. In all postflight tests, the leg volume change again resembled those seen preflight.

Heart rate at rest tended to vary from test to test, and was generally comparable to preflight rates. The stressed heart rate in all crewmen became higher in a somewhat cyclic pattern during flight without definite evidence of a leveling-off trend. Blood pressure changes at rest usually were within preflight ranges. In each crewman, lower body negative pressure stress caused either diastolic pressure or pulse pressure to become lower, again periodically, but particularly in the latter half of the flight. Changes in the heart rate and blood pressure responses to lower body negative pressure were largely confined to the high stress levels.

The Science Pilot experienced symptoms in association with high heart rate and low pulse pressure on visit day 13 during exposure to 0.67 newtons per square centimeter negative pressure. Thereafter, negative pressure during the last 5 minute period of exposure was kept at 0.53 newtons per square centimeter. The Science Pilot again experienced symptoms at this level on the last test performed on visit day 25. In both instances, the test was terminated early. On visit day 18, the Pilot's test was terminated during the last 5 minutes while negative pressure was 0.67 newtons per square centimeter. Although the Pilot did not experience symptoms, the Pilot's heart rate had increased and the pulse pressure had decreased to levels indicating that symptoms would have occurred. In subsequent tests, the final period of negative pressure was also held at 0.53 newtons per square centimeter for the Pilot.

Recovery day cardiac X-rays show a decrease in heart size with the Commander showing the least change and the Science Pilot the most.

The Commander had not quite returned to his preflight baseline on the 20th day after recovery. The Science Pilot was essentially at baseline on the 24th day after recovery, and the Pilot reached baseline on the 21st day after recovery.

4.2.6 Experiment M093 - Vectorcardiogram

The objective of experiment M093 is to measure inflight electrocardiographic potentials of each crewman for comparison with preflight and postflight data.

Data shows only minor changes during the inflight phase of the visit and more marked changes during the postflight period. With the exception of increased heart rates in the postflight period, the electrocardiographic changes observed were not consistently present in all crewmen, nor were any changes associated with clinically significant patterns.

4.2.7 Hematology

Periodic blood samples were obtained from each crewman at regular intervals prior to flight, during flight, and after the flight, and distributed for analyses according to the protocols of M071, M073 and the M110 series.

The inflight blood collection system was utilized four times during the first visit. During each use, blood was drawn from each crewman, transferred to the automatic sample processor, centrifuged and placed in frozen storage. For the first and last sampling, a small vial of blood with a fixative was also prepared. The hardware performed normally. However, a minor procedural change was made to leave the automatic sample processor on the vacuum adapter until ready to inject the blood. This prevented leakage in the automatic sample processor. The centrifuge and automatic sample processor worked normally. All automatic sample processor samples of plasma and cells were good.

Each of the crewmen had blood drawn as shown in the following table.

Period	Total number blood draws	Total blood drawn, milliliters
Preflight	7	400
Inflight	4	44
Postflight	7	365

4.2.7.1 <u>Experiment M111 - Cytogenetic Studies of the Blood</u>.- The object of experiment M111 is to determine the genetic consequences of long duration space flight. Data analysis are in progress.

4.2.7.2 <u>Experiment M112 - Hematology and Immunology</u>.- Experiment M112 is designed to assess changes in humoral cellular immunity. No significant change was noted in the postflight total serum proteins and serum protein electrophoresis, serum immunoglobulins, serum transport proteins, and serum protease inhibitors. Slight C3 and lysozyme changes were noted postflight.

No significant change occurred in the unstimulated ribonucleic acid and deoxyribonucleic acid synthesis rates. However, postflight, a slight but definite decrease did occur in the Commander and Science Pilot's phytohemaglutinin stimulated ribonucleic acid and deoxyribonucleic acid synthesis rates. The changes noted postflight are, in general, relatively minor and are not expected to be of clinical significance.

4.2.7.3 Experiment M113 - Blood Volume and Red Cell Life Span.- Experiment M113 is designed to determine the effect of weightlessness on plasma volume and red blood cell populations.

The major changes in experiment data from the preflight baseline are as follows:

a. Mean red cell mass decreased about 14 percent. Data are not yet available to determine if this was a hemolytic event or inhibition of erythropoiesis.

b. Plasma volume decreased 10 percent in the Science Pilot. Changes in the Commander and the Pilot were insignificant.

4.2.7.4 Experiment M114 - Red Blood Cell Metabolism.- The purpose of experiment M114 is to determine any metabolic and/or membrane changes which occur in the human red blood cell.

On the completed inflight studies, which include methemoglobin, reduced glutathione, and acetylcholinesterase, there are no major changes between the preflight and inflight periods.

4.2.7.5 Experiment M115 - Special Hematologic Effects.- A reduction in the red blood cell count, hematocrit and hemoglobin concentration was measured on the day of recovery and one day later. The red blood cell count had returned to the preflight levels during the examinations conducted on the fourth and seventh days after recovery, but the hematocrit and hemoglobin remain below preflight levels.

An absolute lymphopenia was observed in the Pilot on the day of recovery. All other white blood cell counts and differentials have been within normal ranges. Most special hematology data are still being processed.

4.2.8 Experiment M131 - Human Vestibular Function

Experiment M131 is performed to obtain data on semicircular canal stimulation and spatial localization under conditions of weightlessness. A chair like device is used to position and rotate the subject at several optional constant angular velocities and accelerations.

All experiment hardware performed nominally with the exception of the Velcro seatbelt which would not latch securely. Inflight modifications were made and the problem was corrected.

The major changes in experiment data from the preflight baseline are as follows:

a. The oculogyral illusion was generally more difficult to perceive in flight. On the third day after recovery, the perception of the oculogyral illusion was similar to that obtained preflight.

b. Preflight measurements established normal and similar levels of motion sickness susceptibility for both participants. In flight, the initial mock rotation tests of susceptibility evoked only minimal and transient symptoms. Subsequent tests at the baseline and progressively higher rates of rotation demonstrated a marked decrease in susceptibility. Crew communications at the time of recovery indicate their hypersensitivity to head motion upon returning to 1-g conditions. Subsequent postflight measurements were similar to preflight measurements and established that the crewmen rapidly readapted to vestibular stressor stimulation under 1-g conditions.

4.2.9 Experiment M133 - Sleep Monitoring

The M133 experiment is designed to permit the first objective study of sleep characteristics during prolonged space flight. Brainwaves, eye motion, and head motion signals are processed and the resultant sleep stage information is evaluated.

During the initial activation of the experiment, the Science Pilot discovered that the sleep caps obtained from the stowage compartment for the first visit, located in the sleep quarters, were not providing adequate data. Subsequent inspection of other caps in this stowage compartment indicated that the electrolyte on the electrodes had dried to the extent that would cause this problem. The Science Pilot used caps stowed in the upper ring locker with success for all subsequent runs. An electrode rejuvenation kit will be carried on the spacecraft for the second visit to allow the Science Pilot to inject electrolyte into each electrode of the "dry" caps to correct the problem. Satisfactory data were received on 10 of the 12 runs.

Analysis showed that the magnetic tape was largely unreadable. A new tape is being carried on the next flight to support the second visit. Loss of the bulk of the tape recorded data meant heavier reliance on the results obtained inflight from the onboard automatic analyzer. See section 17.2.12 for further discussion of this anomaly.

The sleep latency, which is the amount of time it takes a subject to fall asleep after beginning the rest period, averaged about 38 minutes on the three preflight baseline nights, and averaged 16 minutes on the inflight nights.

The total sleep time averaged 6 hours 55 minutes preflight, and averaged 6 hours 1 minute inflight, a decrease of almost 1 hour. The Commander and Pilot also exhibited decreased inflight sleep time (approximately 5 to 6 hours) without apparent functional loss.

Preliminary sleep stage analysis shows that the rapid eye movement stage, which is the period strongly associated with dreaming, averaged 22.2 percent prior to flight and was 19.7 percent during flight, an insignificant change. Stage 1 was 5.3 percent prior to flight, and 4.4 percent in flight. Stage 3 also exhibited little change, averaging 14.8 percent prior to flight and 16.2 percent during the mission. Stages 2 and 4 do show a change, however, which, while it appears to be significant, does not imply a degradation in sleep quality. Stage 2 decreased, but stage 4, which was only 2.9 percent prior to flight, rose to 16.5 percent in flight.

4.2.10 Experiment M151 - Time and Motion Study

The purpose of experiment M151 is to study the adaptability, mobility, nd the fine and gross motor activity in work and task performance during space flight. Motion pictures were taken prior to flight and during flight to allow task evaluations. No results are available at this time because film processing time has not permitted completion of the analysis.

4.2.11 Experiment M171 - Metabolic Activity

Experiment M171 is an exercise response test which utilizes a bicycle ergometer to study man's metabolic effectiveness to do mechanical work.

The inflight protocol was run every 4 to 5 days during the 28 day mission and the following parameters were measured: heart rate, blood pressure, respiratory gas exchange (oxygen consumption, carbon dioxide production, minute volume), and electrical activity of the heart. Additional preflight and postflight measurements included: cardiac output, carotid pulse, and vibrocardiogram.

The lap and shoulder harness restraint was very difficult to use in zero g. Consequently, the crew did not use the restraint and, instead, found that the best method to restrain themselves. The crew used triangle shoes, which lock into the bicycle pedal structure, or they put their hands against the ceiling during the pedaling process or used the normal handlebar configuration.

All operations of the M171 metabolic analyzer and ergometer were nominal except for the Pilot's run on the first day and Science Pilot's run on the second day which were terminated early because of high temperatures in the Orbital Workshop and difficulties with the ergometer restraint harness. The original flight plan required only five M171 runs per crewman. However, because of certain physiological changes observed, a realtime decision was made to perform the M171 experiment on each crewman every third day beginning with visit day 15, resulting in the increased number of runs.

A hard-mounted restraint system is planned for the second visit. The system will be evaluated in flight and a determination made for standard procedural usage.

A review of the M171 inflight trend data indicates that after the original ergometer restraint system was discarded, all crewmen approached baseline exercise response values throughout the remainder of the flight. The Pilot, however, did exhibit slightly elevated heart rates at the third level of exercise.

In general, an immediate postflight decrement in exercise tolerance has been observed which is of the same order of magnitude as observed during Apollo. The return to normal has been extended beyond that normally observed during Apollo (with the exception of Apollo 15). All crewmen have now tended to level off in their postflight response to exercise.

4.3 EARTH OBSERVATIONS

The Skylab Earth Resources Experiment Package, composed of six remote sensing systems, provides a spaceborne facility for use as a part of, and in support of, the already existing broad base international studies on the techniques and application of earth remote sensing. These studies encompass multispectral (ultraviolet, visible, and infrared through microwave) sensing at ground level, by aircraft, and by unmanned spacecraft in addition to the Skylab studies.

The Skylab Earth Resources Experiment Package provides additional and more precise data on spacecraft sensing capabilities, allowing a more thorough evaluation of sensor techniques and returned data correlation and application. Also, Skylab offers unique features not presently possible with automated unmanned systems. These are the ability to evaluate test site conditions; to acquire and track uniform, small test sites off the ground track; and to vary the data acquisition activities as system conditions warrant.

This section describes the performance of the Earth Resources Experiment Package hardware during the first visit. Specific sensor evaluation performance is contained in reference 3. Eleven orbital data passes were performed.

4.3.1 Experiment S190A - Multispectral Photographic Facility

The Multispectral Photographic facility and associated electronic hardware operated satisfactorily throughout the first visit.

The flight film originals were evaluated to assess the performance of experiment S190A as an optical system (lens, filter, and Multiple Docking Adapter window). Detailed examinations of imagery of large urban population centers with readily identifiable ground targets were performed. This initial assessment shows that the optical system performed quite satisfactorily.

Some contamination of the aft lens element (reseau plate) was evident on all stations. This contamination resulted from particulate material appearing at random locations in the image area and was usually transient in nature. However, some remained for an entire pass, but was usually dislodged when the magazine was removed. The crew reported that the reseau plates were cleaned only once during the visit. Accumulation of emulsion dust had been anticipated as a result of ground tests, but the accumulation was minor and had a negligible effect on the data.

In conjunction with the film review, the mechanical performance was assessed. Sharpness of the reseau marks imaged on the film showed that the magazine pressure platens provided good contact of the film with the reseau plate. No discrepancies were noted in frame spacing or in the rotary shutter operation. On every data pass, the camera executed the number of exposures commanded. No mechanical problems affecting experiment results were identified, although malfunction lights were illuminated following magazine changeout. This condition is attributable to film loosening on the spool and is discussed in section 17.2.2.

Electrostatic discharge markings, though very random and of short duration (10 frames or less), were evident on approximately 5 percent of the black and white film. Although the markings caused some degradation of imagery, no actual loss of data occurred. A discussion of this is included in section 17.2.6. Film scratching or marks of both plus and minus density were very minor and limited primarily to the beginning of those rolls not threaded in magazines during launch.

Desiccants for the camera were saturated more rapidly than expected, causing more frequent changing. This necessitated bake-out using the fecal oven.

4.3.2 Experiment S190B - Earth Terrain Camera

The Earth Terrain Camera was used during seven passes, including a lunar calibration pass. Performance of the Earth Terrain Camera was good. The clock coupled to the camera was checked on visit day 26 and was 30 minutes and 58 seconds slow and was anticipated based upon preflight tests. This situation posed no problem with the data.

A "hissing" noise was heard while using the spare magazine. This condition is attributed to a leak in the vacuum line connection as discussed in section 17.2.5.

Exposure errors that were experienced were primarily the result of a lack of adequate exposure compensation for sun angle changes. Sun angles for subsequent missions will be calculated using the position of the spacecraft at the time of exposure rather than at the midpoint of a multiple exposure site as was done on several passes during the first visit.

4.3.3 Experiment S191 - Visible and Infrared Spectrometer

The spectrometer performed satisfactorily. The acquisition and tracking of targets using the viewfinder tracking system was accomplished without difficulty. No problems were experienced which adversely affected the short wavelength (visible and near infrared) data. However, a slight shift was observed in short wavelength (lead sulfide) detector output during auto calibration. This shift is attributed to a larger than expected gradient between the short wavelength detector temperature and the package temperature. This will be compensated for by adjusting the package temperature output to accomodate the increased gradient.

The long wavelength (far infrared) data were degraded during the first five passes because of high detector temperatures. This resulted from improper thermal conditioning of the cryogenic cooler and, consequently, insufficient cooling of the detector prior to starting the data passes. Proper thermal conditioning of the cryogenic cooler was achieved prior to the beginning of the sixth pass, because more electrical power was available. After achieving proper cooler operating temperature, data acquisition was normal.

In one instance, the data acquisition camera used in conjunction with the viewfinder tracking system continued to run after being turned off. This discrepancy had been experienced during ground testing and contingency procedures had been established. Camera operation was normal after the film magazine was removed and reinstalled. An error in the checklist caused both rolls of film to be overexposed, resulting in poor image quality. The image quality was improved on the second roll of film by making corrections in the film processing. Few targets were identifiable on the first roll, but the majority of targets were identifiable on the second roll. The data covering the last two passes were severely degraded due to underexposure caused by an inadvertent fast shutter speed setting. This resulted in the gimbal angle and time readouts not being visible on some of the film. Shutter speed will be determined for each pass during the second and third visits.

The television camera was operated twice with the viewfinder tracking system. Operation was normal except for the presence of random spots in the picture. This condition was attributed to the television system and is discussed in section 17.3.4.

4.3.4 Experiment S192 - Multispectral Scanner

The housekeeping data indicated normal instrument operation; however, the science data disclosed several problems, some of which can be compensated for in data reduction. Imagery data from pass 4 exhibited dark and light stripes at a frequency of approximately 1.5 kHz. The effect of the stripes varied from band to band with increasing intensity toward bands 1 and 11. This effect has been attributed to the align switch being left on during this pass and the detectors sensing the 1.5 kHz modulation from alignment light emitting diodes. Post-mission tests produced similar results.

Data showed a low-frequency noise with peaks at approximately 8 Hz, 12 Hz, and 20 Hz superimposed on all channels. The noise did not have a significant effect on any of the channels except the thermal channel which has the highest gain. See section 17.2.7.

The alignment of the thermal channel had shifted from its calculated setting. The crew performed a thermal realignment, but the focus control reached its mechanical stop before a peak reading was obtained. Data indicate that the thermal channel is giving an estimated resolution of about 3.2° K versus the specification value of 1.25° K.

The sensitivity of the thermal channel is lower than expected. This is caused by a non-optimum alignment and the low frequency noise. The 20 Hz noise is most prominent and is apparently caused by cooler vibration. Data reduction techniques have been developed to correct the data and minimize the effect of the noise. See section 17.2.7.

A reduction in the amplitude of the calibration pulse in the fixed gain channels (1, 2, 3, 4, 5, 7, and 8) was noted and this suggests a slight misalignment of the visible channels. Correction factors are being applied to the data. The noise equivalent change in reflectance values obtained from flight data is similar to that obtained preflight. In general, exceptions to this would be bands 4, 5, and, possibly 7, if the correction factors discussed previously are applied. These channels had attenuators installed, which decreased the signal to noise ratio.

Examination of closeout photographs has indicated a possibility that the cooler dewar assembly may not have been properly secured, thus permitting a variation in the alignment. Realignment procedures and equipment are being provided for the second visit.

4.3.5 Experiment S193 - Radiometer/Scatterometer/Altimeter

The performance of experiment S193 resulted in generally good data, although several problems occurred. The radiometer automatic gain control saturated during altimeter operation, resulting in a partial loss of the radiometer data when radiometer operation followed altimeter operation. Two frames of data were missing from altimeter mode 3 data (less than 1 percent). The altimeter pulse compression network used in mode 5 failed, but the short pulse operation is acceptable. The antenna gimbals did not slew out far enough to reach the larger scan angles. Errors of 1 to 6 degrees are present and some of the scatterometer data were degraded. With special processing, the data are usable. The problem resulted from excess stiffness in the antenna gimbal harness. This problem was noted during ground testing and was corrected for small scan angles; however, the difficulty of simulating zero g obscured the problem for larger scan angles. These anomalies are discussed in section 17.2.8, 17.2.9, and 17.2.10.

At the start of the first radiometer/scatterometer operation of pass 1, the antenna failed to move off nadir as commanded. The problem did not recur during any of the following 10 passes. The hangup is believed to have been caused by incomplete release of the launch lock pin used to restrain gimbal movement from launch vibration.

The altimeter nadir alignment did not function properly on the first pass because the Workshop attitude was too far off the nadir. Reconstruction of the altimeter return pulse shape from the sample and hold gate data on the first attempt did not match the expected return. Further analysis verified that the data were valid. The return pulse shape was distorted due to decreasing altitude, off nadir attitude angles, and the associated delay in the tracker's ability to follow the changes in altitude.

As expected, the altimeter lost lock many times over land, especially over rough terrain, and at land-water interfaces. Operation over water was excellent since the altimeter was designed for this type of operation.

4.3.6 Experiment S194 - L-Band Radiometer

Performance of experiment S194 was satisfactory and data quality was good. However, the electronics enclosure temperature was several degrees colder than the design level. This may require adjustments in the science data, depending on the results of ground testing.

4.3.7 Tape Recorder

Review of data from magnetic tape recorder 1 for all passes indicated normal signal characteristics except for one 2 minute period on data track 5 during data pass 11. Since the data on track 5 were also recorded on track 6, no data were lost. Intermittent loss of synchronization and a gradual decrease in the equalized reproduced signal amplitude followed by an essentially instantaneous recovery was evident during this time interval. This type of amplitude decrease is a characteristic of oxide buildup on a recording head followed by an instantaneous self cleaning action. The recorder heads and tape path were cleaned after the removal of a reel of recorded magnetic tape and the recorder heads were cleaned after the completion of each data pass.

The data review from tape recorder 2 indicated normal signal characteristics except for data tracks 3 and 13. The equalized reproduced signals for data tracks 3 and 13 were noisy. Numerous losses of synchronization occurred during ground electronic data processing which probably were caused by this condition. The data on tracks 3 and 13 are also recorded on tracks 4 and 16. Therefore, no data were lost.

Tape recorder 2 operation was satisfactory until the second recording periods of the experiment S192 during passes 3 and 4 when the crew reported that the tape motion light blinked and went off for short periods of time. Although this condition had no affect on the data, this anomaly is discussed in section 17.2.4.

All returned tapes were examined visually. Tapes 1, 3, 4, and 6 showed some sign of layer to layer adhesion and a trace of a tacky residue.

Two reels of tape are being resupplied for the second visit. This is required to replace one reel of tape which was returned for ground test and one reel of tape which came from a known bad web.

5.0 ENGINEERING AND TECHNOLOGY

5.1 ENGINEERING

Crew operations experiments consisted of the experiments M509 (Astronaut Maneuvering Equipment), M516 (Crew Activities), and M487 (Habitabilit and Crew Quarters). The M509 experiment was not performed. Experiments M487 and M516 utilized onboard equipment. No special hardware was required and performance encompasses the habitability activities of all crews. A final report will be made on these experiments at their conclusion.

5.1.1 Experiment M509 - Astronaut Maneuvering Equipment

Activities on the M509 experiment were restricted to unstowing and checkout of the maneuvering equipment. The onboard checkout of experiment M509 used the normal preflight procedures, but without installation of a battery. The unit was not released from the donning station. The pressurized propellant tank was installed and the unit powered up using the external power cable. The thrusters were heated and the manifold pressurized. All translational and rotational commands were verified in the direct mode. The hand held maneuvering unit was attached and the tractor and pusher thrusters were operated. When the control moment gyros came up to speed, the unit was powered down. Data indicates that all systems functioned properly. The battery charger, rate gyro mode, and control moment gyro mode were not operated.

The maneuvering unit was not operated on the first visit because of the uncertain condition of the batteries. The 322° to 327° K temperature inside the Orbital Workshop during the first 10 days of the visit caused concern that the batteries may have been damaged. Subsequent analyses and tests have shown that the batteries are acceptable, subject to verification of cell voltages.

5.1.2 Experiment M487 - Habitability and Crew Quarters

Despite the initial heat, the crew adapted extremely well and, with a portable fan pulling hot air out of the Orbital Workshop toward the Multiple Docking Adapter, they moved in and set up housekeeping. They used both digital temperature sensors and the ambient thermometers to track air temperature and surface temperature through the first several days. The crew did get cold in the Multiple Docking Adapter and wore the jacket when on station at the Apollo Telescope Mount.

The Multiple Docking Adapter is a relatively noisy vehicle with approximately 65 dB ambient on working days.

No measurements of air movement were made, but there is enough flow to move unrestrained items around. Anything that is lost can usually be retrieved a day or two later on the vent screens.

Light levels were too low and the crew advised that extensive use was made of the penlights, especially during the low power phase.

The crew oriented to the coordinate system of the vehicle and strongly tended to maintain the same body orientation while accomplishing tasks in flight as they did during training. The crew translated about the lower floor of the Orbital Workshop in an erect manner and advised that the doorways were properly configured and should not be reduced to porthole size and shape.

The wardroom is small for three man occupancy. With all three crewmen at the table, the table is too close to the pantry wall to allow passage. Therefore, someone has to move to allow passage or the crewmen has to fly over the table, which is undesirable. Windows for looking at the earth are very desirable and they should be large (no smaller than the present Orbital Workshop window).

The trash collection provisions in the wardroom were inadequate. Each crewman should have a trash recepticle at his eating station.

The crewmen were quite mobile and were able to translate from point to point accurately and efficiently. Restraint at various points was essential to the effective conduct of the operations to be done there and, for the most part, the inventory of restraint devices served well. In some instances, however, a more positive means of retention was deemed desirable. For example, the Velcro lap belt on the M131 experiment chain did not keep the crewmen from having unwanted body excursions during chair rotation. Also, the harness arrangement for the bicycle ergometer was ineffective in retaining the crewmen in the proper position. For normal activities, as a matter of convenience, the crewmen used the toes of their shoes in addition to the cleats on the bottoms of the shoes as a means of temporary restraint. This use of the shoe led to abrasion of the toe area, necessitating inflight repair with tape.

The crew's comments concerning the interface between the food and the wardroom was that it was absolutely impossible to prepare and consume food without a good deal of spattering. The room where this takes place should be as spatter-proof as possible with solid flat features like the waste management compartment rather than the nooks and crannies of the wardroom with its open grid ceiling and floor. A lot of the debris escapes and makes cleaning a chore.

Personal hygiene was accomplished without difficulty, with most of the items and systems working quite well. All the waste management facilities functioned satisfactorily. The shower not only worked fine but was a popular item with the crew.

The various combinations of clothing afforded a variety of configurations that were adaptable to the varying environmental conditions throughout the mission. The crew did, however, express a desire to have a long sleeve shirt as a middle point between the current short sleeve shirt and the jacket, which was a bit more bulky and cumbersome than needed for slightly reduced temperatures. Additional garments will be carried by the second visit crew.

The primary leisure activities were earth watching out the window and personal exploitation of the wonders of zero g. A favorite pastime was listening to taped music.

5.1.3 Experiment M516 - Crew Activities/Maintenance

The M516 experiment contains four basic elements to be investigated: (1) manual dexterity, (2) locomotion, (3) mass handling and transfer, and (4) maintenance. The prime sources of data are visual (16 mm onboard photographs and television) and subjective crew comments.

The photographic targets are selected preflight in order to develop the best possible scene characteristics and minimize the crew time required to set up the scene during flight. Approximately 70 percent of the data takes planned preflight were actually accomplished during the visit. The quality of the data is very good and, when analysis is complete, there should be some significant contributions to be made to future designs, especially in the area of maintenance.

No significant differences have been observed thus far between preflight performance and inflight performance of tasks (from a manipulative viewpoint) ranging from gross muscular to fine manipulative. The one most interesting characteristic observed is the simplifying effect that seems to occur in the weightless environment for some tasks when the access envelope for the task is opened up by the absence of gravity.

The preflight hypothesis that handling large masses as a one man task would present restraint and translation difficulties seems to have been disproved. The only limiting factor on handling large masses seems to be adequate provisions for grasping the item, and its not being of such size that the view of the path of movement is restricted.

Various maintenance tasks with which the crew was confronted are discussed in other sections of this report. The tools used, the procedures used, the work sites employed, and the results achieved will be further analyzed in the final report.

5.2 TECHNOLOGY

There were two technology experiments planned on the first visit. One of these, experiment T025 (Coronograph Contamination) was not performed because of unavailability of the solar airlock. Most of the objectives of experiment D008 (Radiation in Spacecraft) were accomplished. This experiment was performed in the command module. The levels of all nine of the telemetry channels from the experiment active dosimeters were in the anticipated range. The passive dosimetry portion of the experiment appears to have operated perfectly. The hardware performed normally.

6.0 FOOD AND MEDICAL OPERATIONAL EQUIPMENT

6.1 FOOD

Food and water to support three visits were launched in the Orbital Workshop. The initial food and accessory weight of 952 kilograms is divided into five food categories: dehydrated food, intermediate moisture food, thermostabilized food, frozen food, and beverages. The initial onboard water weight of 2722 kilograms was stored in 10 circumferentially located stainless steel storage tanks. The non-frozen foods were designed to be stable and wholesome for periods of up to 2 years at temperatures below 303° K. However, ambient food locker temperatures were recorded at up to 333° K during the first 2 weeks after launch. Also, after Orbital Workshop deactivation, food freezer temperatures indicated an equipment malfunction (temperatures up to 265° K were recorded). The cause of the malfunction was not determined, but the temperatures began to return to specification ranges after manipulation of controls by ground command.

Ground tests were initiated to simulate the temperature profiles experienced by the food supplies to enable accurate prediction of problems with crew safety, nutrient quality, and palatability. Test foods were exposed to temperature profiles representing those experienced in flight and the control sample foods were held at 294° K. The test will be completed at the end of the third visit. The six food items that were returned for evaluation show that the ground tests are more severe than the flight conditions.

The Skylab food system and ancillary equipment experienced problems in several areas.

a. Rehydratable package problems were:

1. Separation of a corn spoonbowl package seam.

2. Excessive gas in the water. (Identical problems occurred on the Apollo missions.)

3. Seepage through the zipper closure on the spoonbowl package when kneading.

4. Two can pull tabs failed.

b. Beverage package problems were:

1. An instant breakfast drink had beverage powder in the rehydration valve.

2. The memory of the plastic bellows allows the package to expand and introduce some gas.

c. The catsup packages leaked because the folded configuration caused breaks in the wrapping.

Several food items changed taste, probably because of:

a. The high thermal profile.

b. Changes in crew taste preference.

c. Insufficient food item reconstitution time.

d. Entrapped gas in the water supply.

Specific items noted by the crew were:

a. The bread taste changed.

b. Hard stems were included in the asparagus (should have been tips).

c. The corn did not taste good.

d. The chili was messy.

e. The taste of the rehydratable vegetables decreased as the flight progressed. (A similar situation existed during ground feeding.)

f. The thermostabilized package worked well; however, removal of the membrane prior to eating was messy for some items.

The following food itmes will be supplied on the second Skylab visit:

a. One hundred fifty catsup servings.

b. Approximately 200 vitamin pills.

c. Spices (to improve the bland food taste noted by the first visit crewmen).

d. Food items to compliment the Orbital Workshop overage items (as required to support a 3 day mission extension).

6.2 MEDICAL OPERATIONAL EQUIPMENT

The medical operational equipment performed satisfactorily, except for the carbon dioxide/dew point sensor.

6.2.1 Inflight Medical Support System

The inflight medical support system is utilized primarily as a contingency item; however, the Science Pilot did perform checks of the hardware items. The microscope/slide stainer system was utilized satisfactorily. Minor problems noted during system checks included a ruptured Neosporin ointment tube in the topical drug kit (due to low pressures occurring during Orbital Workshop venting) and the Velcro came off of several bottles containing microbial environmental samples and in general the combination of small pieces of velcro on small items did not work well.

The drugs were exposed to the high temperatures of the Orbital Workshop. A special drug resupply kit was carried on the first visit because of the known effects of temperature on these medications.

6.2.2 Operational Bioinstrumentation System

The operational bioinstrumentation system hardware was used during launch, the three extravehicular activities, and the return and entry phases of the first visit. The system was also used one night to monitor the Science Pilot during sleep. During the third extravehicular activity, the Pilot forgot to insert electrode sponges and no data were received. During entry, the respiration data were poor for both the Commander and Science Pilot. Data analysis shows loose electrodes were the cause.

6.2.3 Carbon Dioxide/Dew Point Monitor

This device was to be used during only the first visit. During activation, a white residue was seen around carbon dioxide sensor A. Subsequently, neither sensors A nor B were operating. Dew point and ambient temperatures were also incorrect relative to Orbital Workshop measurements. Further discussion of these problems is contained in section 17.3.5.

6.2.4 Carbon Monoxide Sensor

Satisfactory carbon monoxide measurements were made in the Multiple Docking Adapter prior to initial entry and in the Orbital Workshop just after entry. A check of the remaining carbon monoxide sensor tubes scheduled for use on the second visit indicated that some tubes had a very slight color change on the outer periphery, but the actual sensor areas were clear.

6.2.5 Toluene Diisocyanate Sensor

The device was specially built for the first crew entry into the Multiple Docking Adapter/Orbital Workshop in order to detect a toxic gas resulting from outgassing because of high Workshop temperatures. The toluene diisocyanate sensor was utilized once in the Multiple Docking Adapter and once in the Orbital Workshop.

7.0 COMMAND AND SERVICE MODULES

This section contains the performance evaluation of the command and service module systems.

7.1 STRUCTURES AND MECHANICAL SYSTEMS

The command and service module vehicle structure and mechanical systems performed normally with the exception of the docking system. Following the successful initial "soft" docking and the subsequent undocking for the standup extravehicular activity, seven unsuccessful attempts were made to achieve docking probe capture prior to the successful docking using the emergency backup procedure. Section 17.1.3 contains a discussion and evaluation of this anomaly.

7.2 THERMAL

Prior to the launch of the Saturn Workshop, the thermal math model previously developed for the command and service module was modified to include the effects of the configuration differences between the Apollo and Skylab command and service module. The model was verified by the data obtained from the thermal vacuum tests and was used to evaluate the Skylab command and service module design, and to predict the flight performance.

Following the loss of a solar array system wing on the Saturn Workshop during launch, steps were taken to minimize the spacecraft electrical power consumption by optimizing the command and service module thermal design for the first visit.

Two thermal design modifications were made which conserved approximately 100 watts. One modification was the partial taping of the command module torroidal section (fig. 7-1) to prevent excessive heat loss from the water tanks and reaction control system propellant tanks. This resulted in a heat loss rate approximately 1/2 that of the original. The other design change was to use the same tape to cover the electrical power system radiator panel 1, 5, and 25 percent of panel 4. The tape increased the temperature of the water/glycol returning from the radiators to the fuel cells, which in turn raised the temperature of the fuel cell water being transferred to the command module through the umbilical. Thus, the water line section in the umbilical would not freeze as long as fuel cell water was flowing through the umbilical. Further, this change assured that the temperatures would remain within the range of the control instrumentation displayed both to the crew and on the ground.

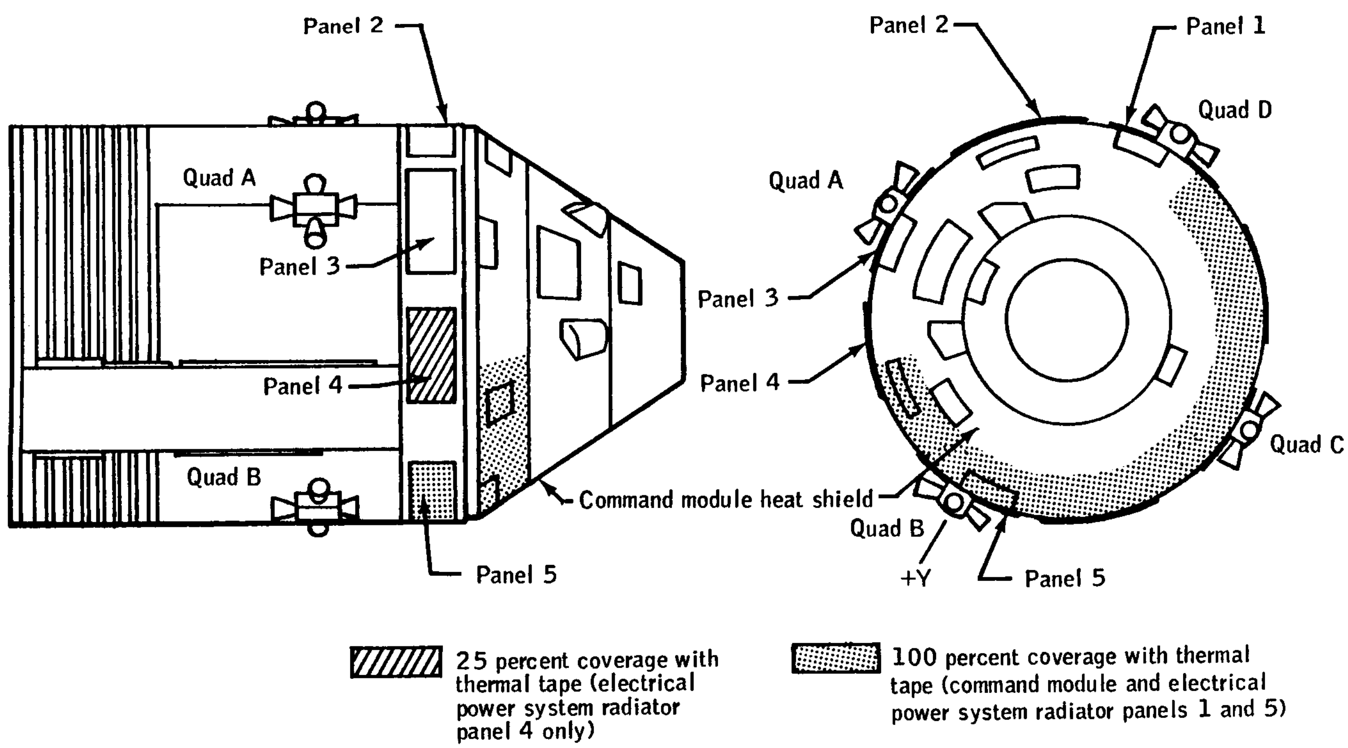


Figure 7-1.- Thermal modification to the first visit command and service module.

Continuous monitoring of 49 temperature and 10 pressure measurements of the command and service module throughout the visit provided data which indicated that the thermal math model should be modified. The modification resulted from changes in the thermal properties of the service module coating. The thermal properties of most of the service module paint required revising as a function of visit time from an absorbtance and emittance of 0.35 (measured prior to launch) to an absorbtance of 0.33 and an emittance of 0.25 (assumed at the end of the visit) because some blistering and peeling of the service module coating had occurred. The paint on the service module reaction control system Quad A door was also assumed to be changed from an absorbtance of 0.22 to 0.35, thus resulting in higher internal temperatures. The modified thermal analysis predicted temperatures which were representative of the flight data (see fig. 7-2).

As a result of the higher absorbtance on the quad A door, the reaction control system quad A helium, oxidizer, and fuel tanks temperatures were higher near the end of the flight than were predicted by the original model. The trend was such that the oxidizer tank pressure would have exceeded the specification limit. The problem was averted by relieving the oxidizer tank pressure into the propellant storage module.

In general, the command and service module temperatures were maintained within acceptable limits. Minimum and maximum temperatures on several significant measurements are shown in table 7-I.

7.3 ELECTRICAL POWER, FUEL CELLS, BATTERIES AND CRYOGENIC STORAGE

7.3.1 Electrical Power Distribution

The power distribution system performed satisfactorily. After docking with the Saturn Workshop, the command and service module was powered down to a low quiescent mode to conserve fuel cell reactants. The total average power for this period was about 1200 watts, a reduction of approximately 200 watts from planned estimates. Upon depletion of fuel cell reactants, the command and service module received power from the Saturn Workshop power sources. After this power source transfer, the command and service module was reconfigured to the preplanned quiescent mode, which for this period was also about 1200 watts. The subsequent power transfers and power levels were normal.

TABLE 7-I.- FIRST VISIT REACTION CONTROL SYSTEM TEMPERATURE DATA

Category/name	Temperature, °K			
	Limit		Recorded	
	Maximum	Minimum	Maximum	Minimum
Quad A				
Engine package	394	286	377	324
Oxidizer line	352	280	331	281
Helium tank	333	280	322	293
Fuel tank	332	274	320	294
Quad B				
Engine package	394	286	Sensor failed	
Oxidizer line	352	280	294	275
Helium tank	333	280	295	282
Fuel tank	332	274	296	282
Quad C				
Engine package	394	286	383	324
Oxidizer line	352	280	295	274
Helium tank	333	280	297	278
Fuel tank	332	274	298	280
Quad D				
Engine package	394	286	376	310
Oxidizer line	352	280	298	272
Helium tank	333	280	300	291
Fuel tank	332	274	297	286

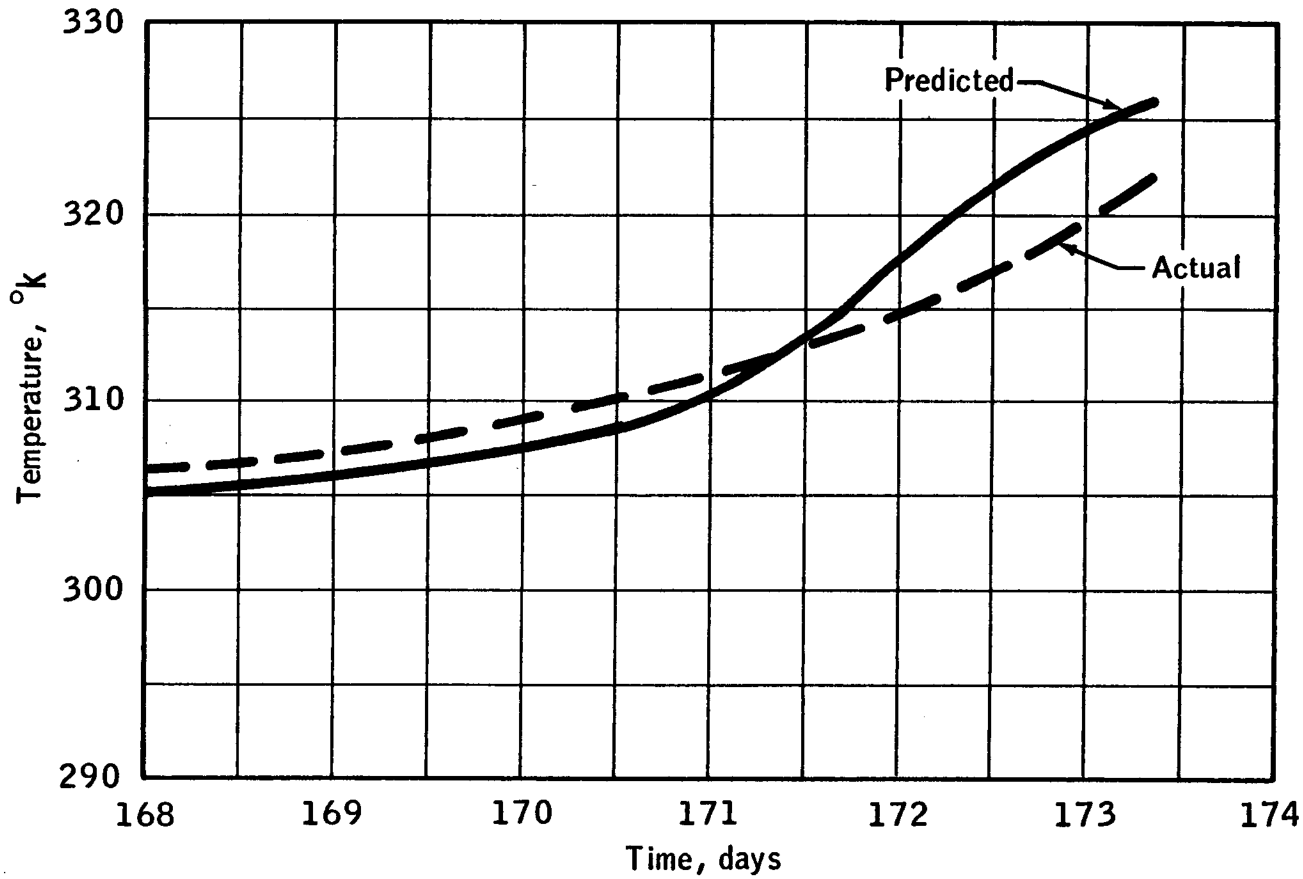


Figure 7-2.- Quad A helium tank temperature.

At 16:18 G.m.t. on the second visit day, there was a main A bus undervoltage indication. A review of data indicated that a command and service module load requiring 16 amperes cycled on and remained on for approximately 5 minutes. This caused the main A bus voltage to drop from 27.7 volts to 25.6 volts, which was the trip point of the undervoltage sensor. Subsequently, the load that had cycled on was isolated to the environmental control system secondary radiator heater. Section 17.1.7 contains a discussion of this anomaly.

7.3.2 Fuel Cells

The first Skylab visit fuel cells were activated on May 13, 1973, during countdown for the planned May 15 launch. When the first Skylab visit launch was delayed for 10 days, an operational evaluation indicated that the fuel cells should not be shut down, but should be kept operating until launch on ground supplied reactants. At launch, fuel cell 1 had accumulated 1072 hours of equivalent operating time and fuel cell 3 had accumulated 562 hours. Although the prelaunch equivalent operating time limit of 840 hours was exceeded for fuel cell 1, a fuel cell changeout was not practical within the constraints of the countdown. Therefore, the prelaunch equivalent operating time limit was waived when supporting test data showed that the limit could reasonably be extended by at least 400 hours with little or no operational degradation.

Fuel cell performance was as predicted from startup up on May 13 to shutdown on June 14 (visit day 21). After launch, the fuel cells operated 485 hours (approximately 20 days). After docking, the average load was approximately 40 amperes.

7.3.3 Cryogenic Storage

The first visit cryogenic hydrogen and oxygen tanks were loaded on May 11, 1973, in preparation for the May 15 launch countdown sequence. Because of the launch delay, the tanks were emptied and reloaded using normal procedures on May 23 to maximize lift-off quantities and, therefore, the duration of available fuel cell power.

The performance of the cryogenic hydrogen and oxygen systems was as predicted. Normal heat leak pressurization resulted in some oxygen being vented into the command module through the "polychoke" selective orifice assembly, and a small amount vented overboard through the command module side hatch non-propulsive oxygen vent. With one exception, the overboard venting occurred after fuel cell shutdown when the oxygen flow demand was reduced to virtually zero.

When the fuel cells were shut down at 17:00 G.m.t. on visit day 21, the non-propulsive hydrogen overboard vent was opened, and the hydrogen system pressure decayed from 164.6 newtons per square centimeter to less than 3.5 newtons per square centimeter in 120 hours.

System performance was normal throughout the mission. Oxygen and hydrogen quantities are summarized in the consumables section of this report.

7.3.4 Batteries

All command and service module batteries performed normally through prelaunch, launch, and docking.

Command module entry batteries A and B supplied the main busses during launch and during all service propulsion system maneuvers, delivering a maximum of 26 amperes from battery A during one of the service propulsion firings. Both batteries performed well.

Two prelaunch charges each were performed on batteries A and B. The first charge replaced approximately 2 ampere hours in each battery; the second charge replaced approximately 5 ampere hours in battery A and 8 ampere hours in battery B. Prior to an inflight charge to full capacity, battery A had delivered approximately 29.5 ampere hours and battery B, approximately 28 ampere hours. Entry batteries A and B were disconnected from the battery busses at approximately 1200 G.m.t. on visit day 4, and the battery busses, minus the batteries, were placed on the main power busses. Battery C remained on open circuit throughout the mission. Prior to deorbit, the capacity status of batteries A, B, and C was 116.5 ampere hours of an original 120 ampere hours. No further charges were necessary.

The estimated capacities remaining at landing were: battery A - 23 ampere hours; battery B - 24 ampere hours; and battery C - 28 ampere hours (margin of 75 ampere hours remaining at landing).

The descent batteries performed as expected. During a launch pad calibration test, 3 ampere hours were consumed from each of the three batteries. During flight, an additional 5 ampere hours were removed from descent battery 2 when it was placed on the main busses momentarily with the two fuel cells raising the main bus voltages by 2 volts during critical docking maneuvers.

Battery 1 delivered an estimated 317 ampere hours, battery 2 delivered 88 ampere hours and battery 3 delivered 305 ampere hours up to command module/service module separation. Batteries 1 and 3 carried the command module loads from internal power transfer at 3:00 G.m.t. on visit day 29 for 5 hours and 21 minutes at which time battery 2 was placed on the bus to assure that the temperatures of batteries 1 and 3 did not exceed the operating temperature limit of 355° K. This configuration was maintained until preparation for command module/service module separation when battery 2 was removed from main bus A to allow entry battery conditioning. The maximum descent battery temperature experienced was 347° K. The total estimated battery capacity usage was 710 ampere hours versus the expected usage of 727 ampere hours. (Total capacity available is 1500 ampere hours).

Pyrotechnic batteries A and B performed their functions satisfactorily, and open circuit voltages remained stable.

7.4 COMMUNICATIONS AND TELEVISION

7.4.1 Communications

The communications system satisfactorily supported the first visit operations.

An unfavorable Saturn Workshop antenna look angle resulting from the Saturn Workshop attitude limited the operating range of the very high frequency ranging system. However, system performance was commensurate with preflight predictions for the resulting antenna look angles.

A problem was experienced with the updata link real time commands wherein the S-band FM transmitter was improperly turned off when other specific functions were commanded. Section 17.1.6 contains a discussion of this anomaly.

7.4.2 Color Television Camera

During the first Skylab visit, the color television camera system performed all of its required functions, although one of the two cameras ceased operation during the visit. Also spots appeared on transmissions from the other camera. Sections 17.3.3 and 17.3.4 discuss these anomalies.

7.5 INSTRUMENTATION AND DISPLAYS

The instrumentation and displays performed satisfactorily during the first visit with the exception of two anomalies. Shortly after launch, the service module reaction control system quad A and the propellant storage module pressure/temperature sensors failed. Section 17.1.2 discusses this anomaly.

At approximately 5:00 G.m.t. on visit day 2, the reaction control system quad B package temperature measurement began reading off scale high. The measurement had occasionally shifted to 350° K, approximately mid scale, for short periods and shifted back to off scale high (427° K). An evaluation of this anomaly is presented in section 17.1.4.

7.6 GUIDANCE, NAVIGATION, AND CONTROL SYSTEMS

Performance of the guidance, navigation, and control system was normal. The only anomaly experienced was an occasional error in the indicated sextant trunnion angle. The problem was circumvented by selecting the zero optics mode before each intended use of the optics. This anomaly is discussed in Section 17.1.10.

At the completion of the launch phase, the on board computer indicated that an orbit of 304.3 by 134.4 kilometers had been achieved. Analysis of the launch phase data indicates insertion errors of minus 0.79, plus 5.10, and minus 1.53 meters/second in spacecraft X, Y, and Z axes, respectively. These compare well with previous missions and indicate normal performance during the launch phase.

After a successful separation from the launch vehicle and completion of spacecraft systems checkout, the rendezvous sequence was initiated. A summary of rendezvous maneuvers is given in table 7-II. The crew reported larger than expected X-axis velocity residuals at the completion of the first phasing, corrective combination, and coelliptic rendezvous maneuvers. The residuals, which were as large as 0.49 meters per second, were caused by allowable variations in engine thrust levels. Each of these maneuvers was less than 6 seconds in duration and the computer uses a short firing logic equation to calculate the thrust time. The computer equation uses a thrust value which was determined during the preflight period, and the equation includes factors for thrust buildup and tailoff profiles, and the number of ball valves to be used for the maneuver. The thrust value stored in the computer assumed that both ball valves would be used (a two bank firing) whereas, only one ball valve was used (a single bank firing). The difference in the thrust value between a single and dual bank operation could account for 0.15 meters per second and the allowable variation of 6672 newton-seconds in tailoff impulse could account for 0.46 meters per second.

Control system performance during the soft docking and the hard docking attempts was normal. The crew reported closing velocities up to 0.65 meters per second. The separation velocity at final undocking was reported as about 0.12 meters per second.

TABLE 7-II.- MANEUVER SUMMARY

Parameter	First phasing	Second phasing	Corrective combination	Coelliptic	Terminal phase initiation	Shaping	Deorbit
Time[a]							
Ignition, G.m.t.	145:15:23:38.16	145:17:41:20.05	145:18:27:27.10	145:19:04:27.10	145:20:03:48.43	173:10:05:28.99	173:13:10:45.80
Cutoff, G.m.t.	145:15:23:47.42		145:18:27:28.70	145:19:04:28.07	145:20:03:49.11	173:10:05:39.92	173:13:11:53.55
Duration, sec	9.26		1.60	0.97	0.68	10.93	7.55
Velocity, meters/sec							
X-axis	62.9	13.6	11.4	6.5	5.5	-78.0	-56.2
Y-axis	0.0	0.0	1.8	1.3	0.2	0.0	0.0
Z-axis	0.0	0.0	-4.0	-5.02	-2.4	19.9	13.9
[b]Residuals, meters/sec (before trim)							
X-axis		0.5 (1.6)		0.4 (1.2)		0.3 (1.0)	0.3 (1.0)
Y-axis		0.0 (0.0)		0.0 (-0.1)		0.2 (0.8)	0.2 (0.8)
Z-axis		-0.1 (-0.2)		0.0 (-0.1)		0.2 (0.5)	0.1 (0.2)
[b]Residuals, meters/sec (after trim)							
X-axis	-0.1 (-0.2)		0.0 (0.0)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)	0.0 (-0.1)
Y-axis	0.1 (0.2)	No trim	-0.1 (-0.2)	0.0 (0.0)	-0.1 (-0.2)	0.0 (0.1)	0.0 (-0.1)
Z-axis	0.0 (0.1)		0.0 (0.0)	(-0.1) (-0.3)	0.0 (0.0)	0.0 (-0.1)	0.0 (-0.1)

[a]Greenwich mean time is shown in day-of-the-year, hours, minutes and seconds.

[b]Residuals are shown in feet per second, as displayed to the crew, in parentheses.

Table 7-III summarizes the platform alignments. A new computer program for Skylab was used while the command and service module was docked to the Saturn Workshop. The purpose of the program was to establish an inertial reference between the guidance system in the command module and the Apollo Telescope Mount digital computer, and to determine the docking gimbal angles. With this information, the sun sensor and star tracker in the Apollo Telescope Mount were used to realign the guidance system platform. The Euler angles between the guidance system navigation base and the Apollo Telescope Mount navigation base were determined after docking and during the entry minus 7 day system checks. The Euler angles are in close agreement and are as follows:

Time	Angular rotation, radians		
	Alpha	Beta	Difference
Post-docking	2.5580	3.1441	0.0037
Entry minus 7 days	2.5576	3.1436	0.0035

Performance during the shaping and deorbit maneuvers was normal. The spacecraft was guided to a successful landing at 24 degrees 46 minutes north latitude, 127 degrees 4 minutes west longitude as indicated by the onboard computer.

7.7 PROPULSION

7.7.1 Service Propulsion System

The service propulsion system operations were normal throughout the visit. Seven maneuvers with a total firing duration of 33 seconds were accomplished.

Five service propulsion system maneuvers were accomplished for rendezvous with the Saturn Workshop. The total firing duration for these five maneuvers was approximately 15 seconds. System operation was normal during and after each firing.

During the docked period, system parameters were normal. Oxidizer tank pressure decayed to approximately 111 newtons per square centimeter primarily because of the temperature decay, causing the caution and warning systems for service propulsion system pressure to be activated as expected.

TABLE 7-III.- PLATFORM ALIGNMENT SUMMARY

Time, G.m.t.	Program option	Star	Gyro torquing angle, rad			Star angle difference, rad	Gyro drift, meru		
			X	Y	Z		X	Y	Z
145:13:50:00	3	25 Acrux, 33 Antares	-0.00017	0.00124	0.00150	0.00000	0.80	-5.68	-6.88
145:13:54:30	2	25 Acrux, 33 Antares	0.00105	0.00131	0.00103	0.00000	--	--	--
145:15:29:00	3	25 Acrux, 33 Antares	0.00016	0.00115	0.00096	0.00000	-0.38	-2.79	2.32
145:17:05:00	3	37 Nunki, 45 Fomalhaut	0.00000	0.00131	0.00058	0.00000	0.00	--	--
166:11:09:45	1	41 Dabih, 44 Enif	-0.00126	-0.00064	-0.00080	0.00000	--	--	--
166:13:15:45	3	37 Nunki, 40 Altair	0.00133	-0.00304	-0.00147	0.00000	-2.41	5.52	-2.67
173:03:02:00	1	45 Fomalhaut, 40 Altair	0.00026	-0.00054	-0.00110	0.00000	--	--	--
173:06:24:21	3	44 Enif, 37 Nunki	0.00209	-0.00380	-0.00176	0.00017	-2.37	4.32	-2.00
173:07:33:46	3	1 Alpheratz, 2 Diphda	0.00064	-0.00112	-0.00070	0.00000	-2.13	3.69	-2.30
173:11:42:46	3	35 Rasalhague, 43 Deneb	0.00223	0.00077	-0.00176	0.00000	-2.05	-0.71	-1.62

After undocking and prior to the shaping and deorbit maneuvers, the propellant tank pressures were equalized by manually activating the helium isolation valves. Firing times for the shaping and deorbit maneuvers were approximately 11 seconds and 7 seconds, respectively. System operation was normal during both maneuvers.

7.7.2 Service Module Reaction Control System

The first visit service module reaction control system was activated on the launch pad by filling the propellant manifolds from the propellant storage module. The system was initially configured to feed the engines from the quad propellant supplies. After 22 kilograms of propellant were used from quad A, the propellant supply for the quad A engines was switched to the propellant storage module. Quad B was switched after 13 kilograms were used, quad C after 17 kilograms, and quad D after 16 kilograms were used. Because of the rapid braking maneuvers, the flyaround, and the multiple docking attempts, propellant consumption and the number of thruster firings were higher than predicted. However, systems performance was normal throughout the mission.

After the command and service module docked with the Saturn Workshop, the service module reaction control system heaters were configured for minimum power consumption. Temperatures were normal except for the quad A propellant tank temperatures which reached 323° K. A discussion of this problem is presented in section 17.1.2.

At approximately 5:00 G.m.t., on visit day 2, the quad B package temperature measurement failed. This measurement is the only direct indication that the engine housing heaters are functioning. This condition required the isolation of the quad as a precautionary measure to ensure that the engines would not be fired at temperatures below safe operating limits. A contingency procedure was developed to allow the quad to be used in cases of absolute necessity by manually cycling the heaters in advance of a preplanned firing. This anomaly is discussed in section 17.1.4.

Because of the instrumentation problem, the system was configured for a two engine, quad A and C, 63 second +X axis firing for the subsequent trim maneuver. Post-firing data indicated that the quad A and C firing was normal, but also indicated some propellant use from quads B and D. The system configuration was determined to be improper. The automatic reaction control system select switches were configured for a four jet +X firing, but the propellant isolation valves were configured for a two jet +X firing. This resulted in the quad B and D jets burning propellant trapped in propellant lines and manifolds. Although this creates a potentially hazardous situation, no system damage was incurred.

Later in the visit, quad B heater operation could be detected by monitoring main bus current loads. Thereafter, the service module reaction control system was configured for normal four quad operation.

As propellant was used from the propellant storage module and quads, the pressure/temperature propellant gaging system on the propellant storage module and quad A apparently had failed (see section 17.1.2). Because these measurements are only used as a backup to ground calculations of propellant utilization, the visit operations were not impacted.

7.7.3 Command Module Reaction Control System

System parameters were normal and remained constant throughout the quiescent portions of the mission. System activation after command and service module/Saturn Workshop separation was normal. The systems operated satisfactorily during entry.

7.8 ENVIRONMENTAL CONTROL SYSTEM

The environmental control system performance was satisfactory during the command and service module active and quiescent phases of the flight. Several anomalies and minor operational discrepancies were noted, but none had any significant visit impact.

The suit to cabin differential pressure remained negative for some periods during the final half hour prior to launch, although the direct oxygen valve was supplying the suited crewmen normal flow. Increasing the flow was ineffective, but on one occasion the indicated leakage stopped and the measurement returned to a positive reading coincident with movement of a crewman's suit hoses. The problem recurred again shortly after launch; however, subsequent inflight suit circuit integrity checks and operation during depressurized cabin conditions were normal. Section 17.1.1 contains a discussion of this anomaly.

During the isolation of the primary coolant loop reservoir, adjustment of the accumulator, and initiation of flow to the radiators, the water/glycol low flow caution and warning light was activated momentarily. Also, a momentary drop in pump pressure and a reduction in accumulator quantity occurred after the accumulator adjustment. A possible cause of the observed system behavior was a partially opened reservoir inlet or outlet valve. Adjusting the accumulator with the valve improperly positioned would momentarily allow sufficient water/glycol to bypass both the coldplate network and the flow measurement location, thus actuating the low flow warning. When the accumulator adjustment was completed with the closing of the accumulator fill valve, the reservoir refilled and the accumulator quantity returned to the previous reading. Subsequently, the primary accumulator was adjusted with no indication of any problems for the remainder of the visit.

Adequate command and service module thermal control was maintained during the docked phase under the adverse conditions of the higher beta angles resulting from the delayed launch as well as the reduced heat loads because of power restrictions. A special outlet temperature transducer was added shortly before launch to improve the ground monitoring capability of the critical (low temperature) active radiator panel. The new transducer enabled control of the panel temperature to a 230° K orbital average with a minimum use of electrical power.

Early on visit day 2, the secondary evaporator outlet temperature transducer failed and the indicated temperature dropped from about 297.4° K to 271.5° K. Also, the secondary heaters activated during a period of extended secondary coolant loop operation on visit day 21, although the heater switch was in the off position. Heater operation occurred at the end of the dark side portions of two successive orbits with the secondary radiator outlet temperature at about the normal activation point. In addition, the secondary radiator inlet and outlet temperature measurements were powered continuously, although the secondary loop circuit breaker was normally closed only during the secondary loop operation. An earlier unexplained main A undervoltage (section 7.3.1), which occurred during secondary evaporator dryout, is also believed to have resulted from an anomalous activation of the heater. Sections 17.1.5 and 17.1.7 contains a discussion of these anomalies.

Operation of several environmental control system components flown for the first time was successful. These included the service module water tank for storing excess fuel cell water, and the cryogenic vent relief valve, the non-propulsive vent nozzle, and the polychoke orifice for reducing excess cryogenic oxygen tank pressure and, thereby, precluding tank venting.

7.9 SPECIAL STOWAGE

As a result of the thermal problems that occurred after the Saturn Workshop launch, several designs were developed to provide the necessary hardware for thermal shielding of the Orbital Workshop. Also, an assortment of tools was collected for use in freeing the solar wing which had failed to deploy. Time limitations dictated that off the shelf hardware be used where possible and, consequently, the resulting flight equipment was large and difficult to stow. All available launch volumes were used by items required to replace hardware degraded by the high temperatures.

Stowing the tools, thermal shields, and deployment devices was accomplished using approximately 61 meters of rope and existing bags from spares to secure the items in available locations. Deletions of 132.5 kilograms and addions of 235.0 kilograms to the first visit baseline command module launch stowage resulted in addition of 102.5 kilograms. Table 7-IV reflects the actual launch weight and center of gravity as compared to limits.

7.9.1 Stowage Relocations

The large quantities of additional hardware required relocating many of the items already stowed. The crew was briefed on all the stowage changes and the complete configuration change was demonstrated using training hardware.

The launch stowage location for the Skylab parasol blocked all access to the water chlorination port, the environmental control unit, and the panel 351 valve controls. Because access to these areas was required shortly after launch (T + 25 minutes), a shroud cutter was used to quickly cut enough of the rope bindings for the required access. The first visit launch stowage configuration outside the stowage lockers is shown in figure 7-3. Couch relationship to stowage items, resulting from a worse case water or land landings, is shown in figure 7-4.

7.9.2 Return Stowage

No significant problems were encountered in defining the command module return stowage. Except for the return of an extra experiment S082 film unit and various samples for thermal analysis, return stowage was basically normal.

Figure 7-5 shows the return configuration outside the command module stowage lockers.

7.9.3 Stowage Differences

Tables 7-V and 7-VI define the first visit launch and return stowage differences from the stowage configuration defined prior to the occurrence of the Orbital Workshop thermal problem.

TABLE 7-IV.- COMMAND MODULE WEIGHT AND CENTER OF GRAVITY

	Actual	Limits
Earth launch weight, kilograms	6076	6124.2
Z axis center of gravity at earth launch, centimeters	9.652	9.652
X axis center of gravity at high altitude burnout, centimeters	4259.80	4259.80
Descent on main parachutes weight, kilograms	5845[a]	5897[a]
Landing weight, kilograms	5606[a]	5654[a]

[a]The weights are applicable to a high altitude abort case with the command module in the launch configuration.

TABLE 7-V.- FIRST VISIT LAUNCH STOWAGE DIFFERENCES
(Additions)

Item	Reason
Accessory bags (2)	Stowage provisions
Atomizer	Increase humidity in Orbital Workshop
Binoculars	Damage assessment
Masks/charcoal canister (2)	Toxic fume protection
Carbon monoxide detector samples	Additional carbon monoxide sampling
Condensate quick disconnect adapter	Transfer of excess water created by extended fuel cell operation
Command module mineral supplement kit	Vitamin loss in food due to heat
Data acquisition camera 43 meter magazine	Flyaround photography
Data acquisition camera 122 meter magazine	Resupply due to heat damage
Earth terrain camera film canister	Resupply due to heat damage
Extravehicular overgloves (2 pair)	Suit glove protection
Food stick (3)	Food for extravehicular activity
Helmet protective shield	Standup extravehicular activity
70 mm magazine	Flyaround
Water servicing quick-disconnect	Water transfer Orbital Workshop-to command module
Inflight medical support system cans H, J, G, K	Drug resupply due to heat damage
In-suit drinking device	Standup extravehicular activity
Jettison bag	Inflight operations
Shroud cutter	Unstowing flexibility
Liquid cooling garment/ pressure control unit water adapter (2)	Liquid cooling garment use without suit
Main display console guards (3)	Standup extravehicular activity
Medical kit	Drug resupply due to heat damage
Nikon 300 mm lens	Damage assessment

TABLE 7-V.- FIRST VISIT LAUNCH STOWAGE DIFFERENCES
(additions) - Concluded

Item	Reason
Pressure control unit restraint belt	Use with liquid cooling garment
Suit wrist tether (2)	Standup extravehicular activity
Marshall Spaceflight Center twin boom sunshade and equipment	Thermal control
Johnson Space Center Skylab parasol and equipment	Thermal control
Johnson Space Center standup extravehicular activity sail and equipment	Thermal control
Standup extravehicular activity visor	Standup extravehicular activity
Sleep restraint	Stowage provisions for the Skylab parasol
Experiment S019 film	Resupply due to heat damage
Experiment S183 carousel	Resupply due to heat damage
Experiment S190 cassettes	Resupply due to heat damage
Gray general purpose tape (3)	Stowage provisions
Tape recorder swabs (4)	Resupply
TDI detector/equipment	Orbital Workshop environment check
Thermal gloves (2 pair)	Handle hot hardware
Tools (8 items)	Repair thermal shield
Temporary stow bag	Tool stowage
Urine collection bags (3)	Standup extravehicular activity
Biomedical urine sample bag	Contingency item for delayed entry into the Orbital Workshop
Visor wipes	Standup extravehicular activity
Waist tether (2)	Standup extravehicular activity
Waste water quick disconnect	Transfer of excess water created by extended fuel cell operation
Waste stowage container	Contingency item for delayed entry into the Orbital Workshop

TABLE 7-V.- FIRST VISIT LAUNCH STOWAGE DIFFERENCES
(Deletions)

Item	Reason
Inflight medical support system	To obtain volume and reduce weight
Calculator assembly	To obtain volume and reduce weight
Contingency food	To obtain volume and reduce weight
Intravehicular umbilical and bag	To obtain volume and reduce weight
Experiment M555 and equipment	Reduced available power and to reduce weight
Panel 603 gage	To obtain volume and reduce weight
Experiment S015	To obtain volume and reduce weight
Experiment S020 film	Scientific airlock window not available
Experiment S063 film	Scientific airlock window not available

TABLE 7-VI.- FIRST VISIT ENTRY STOWAGE DIFFERENCES

Item	Reason
Television and camera lens	Camera failure analysis lens contamination
Anti-fog ampule	Thermal effect analysis
Orbital Workshop drug samples	Thermal effect analysis
Food sample - Orbital Workshop	Thermal effect analysis
Earth Resources Experiment Package tape	Thermal effect analysis
Biocide wipes	Thermal effect analysis
Teleprinter paper sample	Thermal effect analysis
400 foot film cassette	Thermal effect analysis
Carbon dioxide active inlet filter	Thermal effect analysis
Carbon dioxide passive inlet filter	Thermal effect analysis
Drug canister package	Thermal effect analysis
Experiment S082 film	Additional science data
Experiment ED31	Experiment data
Water valve assembly	Valve operational analysis
Experiment S183 film	Additional experiment data
16 mm 140 foot magazine	Additional experiment data
Experiment S183 photographic slide	Additional experiment data
Science Pilot food log	Medical data
Deleted locker A2	Provide space for experiment S082

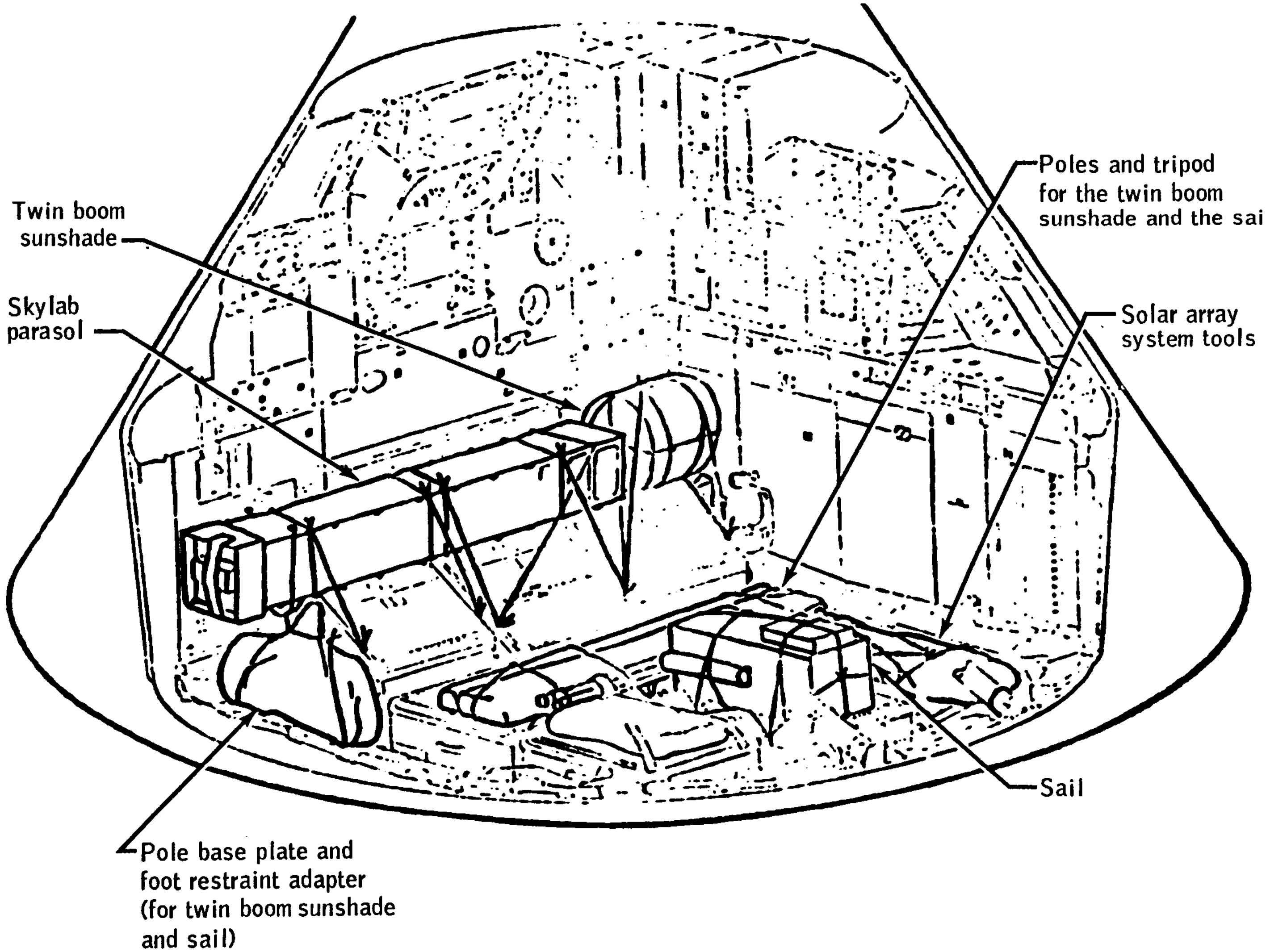


Figure 7-3. - First visit launch stowage configuration.

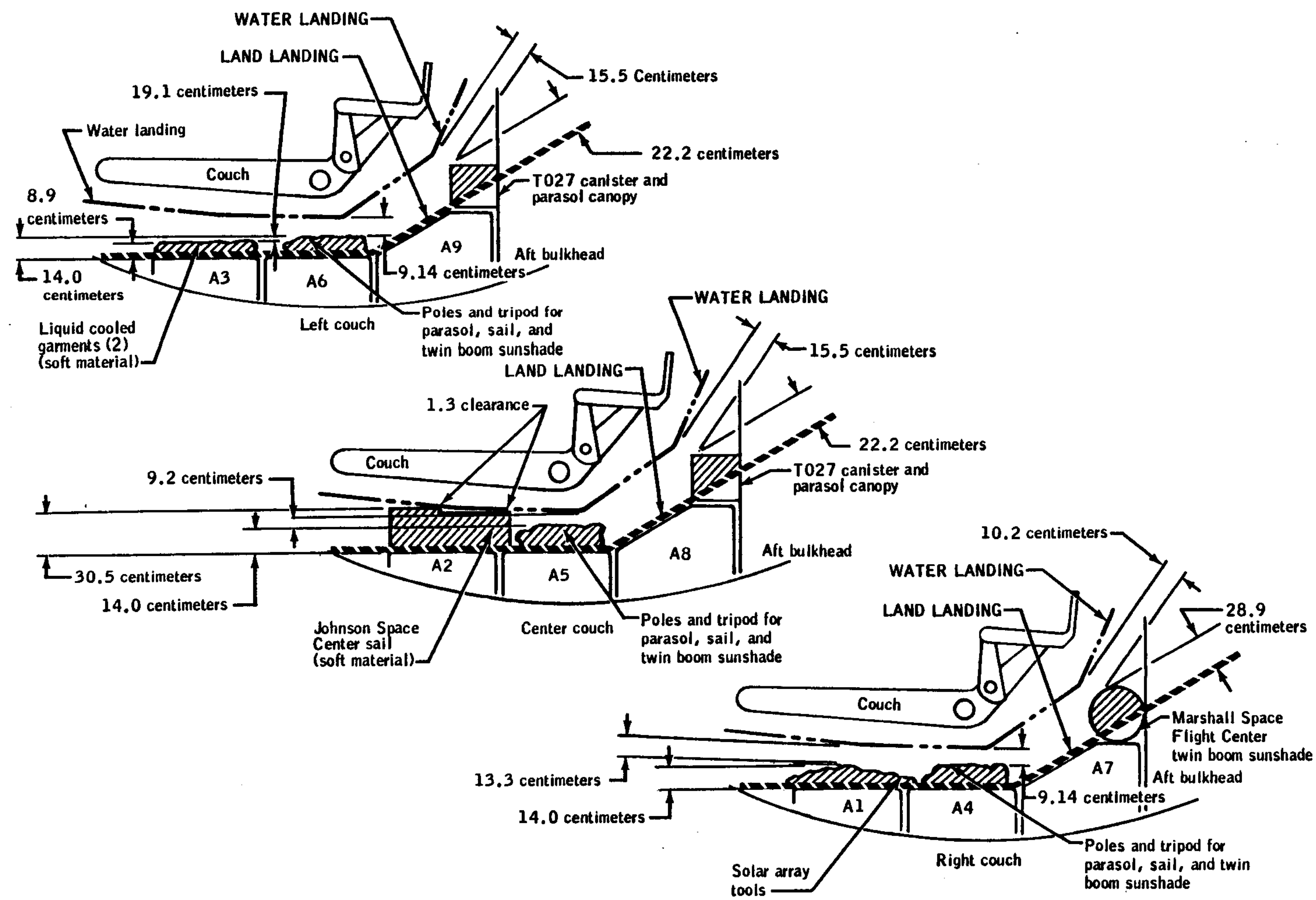


Figure 7-4.- First visit landing attenuation envelopes.

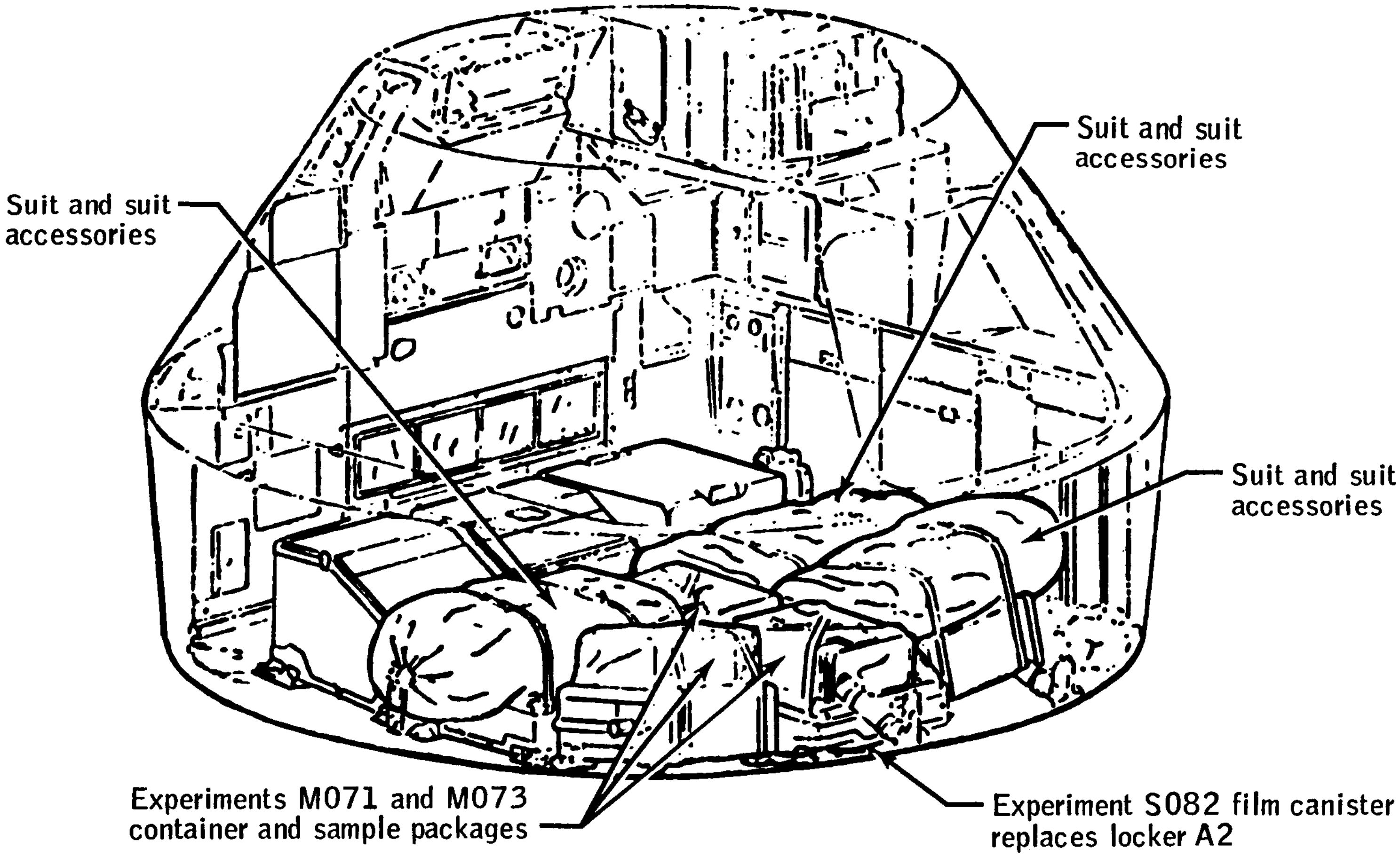


Figure 7-5.- First visit return stowage.

7.10 CONSUMABLES

The command and service module consumable usage during the first visit was maintained well within the redline limits. Specific system usage is discussed in the following paragraphs.

7.10.1 Service Propulsion System

The service propulsion system propellant and helium loadings and consumption values are listed in the following table. The loadings were calculated from gaging system readings and measured densities prior to lift-off.

Condition	Propellant, kilograms		
	Fuel	Oxidizer	Total
Loaded	869	1401	2270
Consumed	426	684	1110
Remaining	443	717	1160

Condition	Helium, kilograms	
	Storage bottles	Propellant tanks
Loaded	19.3	14.2
Consumed	1.9	-1.9
Remaining	17.4	16.1

7.10.2 Reaction Control System Propellant

Service module.- The propellant utilization and loading data for the service module reaction control system were as shown in the following table. Consumption was calculated from telemetered helium tank pressure histories and was based on pressure, volume, and temperature relationships.

Condition	Propellant, kilogram		
	Fuel	Oxidizer	Total
Loaded			
Quad A	49.9	102.5	152.4
Quad B	49.6	101.5	151.1
Quad C	49.3	101.8	151.1
Quad D	49.5	102.0	151.5
Propellant storage module	227.9	461.1	689
Total	426.2	868.9	1295.1
[a]Usable loaded			1184.3
Consumed			572.4
Remaining at command module/service module separation			611.9

[a]Usable propellant is the amount loaded minus the amount trapped with corrections made for gaging system errors.

Command module.- The loading of command module reaction control system propellant was as follows:

Condition	Propellant, kilogram		
	Fuel	Oxidizer	Total
Loaded			
System 1	19.8	41.0	60.8
System 2	19.8	41.0	60.8
Total	39.6	82.0	121.6
Consumed	3.0[a]	9.0[a]	12.0[a]

[a]Based on amount of propellant off loaded.

7.10.3 Cryogenic Storage System

The total cryogenic hydrogen and oxygen quantities available at lift-off and consumed during the flight are as follows. Consumption values were based on quantity data transmitted by telemetry.

Condition	Hydrogen, kilogram		Oxygen, kilogram	
	Actual	Planned	Actual	Planned
Available at lift-off				
Tank 1	12.0		144	
Tank 2	12.1		146	
Total	24.1		290	
Consumed				
Tank 1				
Tank 2				
Total	24.1		263	
Remaining at command module/service module separation				
Tank 1	0		16	
Tank 2	0		11	
Total	0		27	

7.10.4 Water

The water quantities loaded, produced, and expelled during the mission are shown in the following table.

Condition	Quantity, kilograms
Loaded (at lift-off)	
Potable tank	5
Waste tank	25
Produced in-flight	
Fuel cells	212
Lithium hydroxide canister	2
Metabolic activity	4
Total loaded and produced	248
Dumped overboard	25
Stored in Orbital Workshop	36
Lost as urine	15
Evaporator usage	9
Remaining at command module/ service module separation	
Service module tank	129
Potable tank	17
Waste tank	13
Total expelled and remaining	237
Balance	4[a]

[a]Value added to compensate for the inaccuracies of the transducers and uncertainty of the data.

8.0 CREW EQUIPMENT

8.1 EXTRAVEHICULAR MOBILITY UNIT

The performance of the extravehicular mobility units was satisfactory during the first visit. The extravehicular mobility units, in whole or in part, were used as scheduled in the following periods:

a. Launch and boost

b. Standup extravehicular activity

c. Docking

d. Second extravehicular activity

e. Third extravehicular activity

f. Undocking.

During the launch and boost phase, a negative suit to cabin differential pressure occurred. Analysis of this anomaly is discussed in section 17.1.1.

During the second extravehicular activity, problems with the primary thermal control coolant system and the interfacing suit umbilical water system 1 necessitated both extravehicular crewmen connecting their water connectors to suit umbilical system 2. This system interfaces with the secondary coolant system heat exchanger. The third crewman was suited, except for helmet and gloves, in the multiple docking adapter. This crewman also later had to connect to suit umbilical system 2 to obtain body cooling.

An unscheduled usage of the astronaut life support assembly and the liquid cooled garments was required after the second extravehicular activity. A low-temperature problem occurred in the Airlock Module secondary coolant system because of a malfunction of thermal control valve B and the removal of the extravehicular activity thermal loads from the loop. Two sets of pressure control units, life support umbilicals, and liquid cooled garments were connected to the suit umbilical system 2 to put heat into the system. The liquid cooled garments were strapped to the water tanks and the suit umbilical system loop was operated. This operation was maintained until the coolant loop was warmed up and the system operated properly.

The second coolant system was again not modulating properly before the third extravehicular activity and, because a possibility of dislodging potential contamination in one of the heat exchangers existed, this extravehicular activity was performed with all three crewmen receiving water cooling from suit umbilical water system 1 and with the primary coolant system operating in the bypass mode with two pumps. Adequate cooling was obtained by all three crewmen.

Table 8-I shows the heat load imposed by the extravehicular crewman on the extravehicular mobility unit. Because all three crewmembers were on a single water circuit and the water flow to each crewman was not controlled, the flow split could not be accurately determined. Correlating earth based test data with the telemetered liquid cooled garment differential temperature data allowed the flow split to be estimated. Table 8-I is based on liquid cooled garment water temperature response and, thus, some damping of the metabolic rate occurred. Instantaneous metabolic rates based on heart rate data would be expected to reveal higher short term values. In addition, the analysis does not account for any positive or negative body heat storage. The Science Pilot did store significant heat during portions of the second extravehicular activity because of the inconvenience of manipulating the diverter valve, which resulted on the high heat load peak. Similarly, the Commander was hot toward the end of the third extravehicular activity and this indicates body heat storage and accounts for the relatively low heat loads for the Commander during the third extravehicular activity.

8.2 CREW PERSONAL EQUIPMENT

Numerous crew equipment items were used throughout the mission. All operations with this equipment were normal except one of the wind-up razor heads became rough and scratchy during use and the bonded blade type razors could not be sufficiently cleaned. For the next visit, new razor heads and extra double edged razors and blades are being supplied.

The high Orbital Workshop temperatures damaged the supply of toothpaste, hand cream, shaving cream, and deodorant. Therefore, these items will be resupplied on the second visit. In addition, the third visit crew requested that after shave lotion be supplied.

The boots from the clothing modules were wearing out at the toes. The boot toes were redesigned with a material that has two times the abrasion resistance of the present material. Nine pair will be launched on the second visit.

TABLE 8-I.- FIRST VISIT EXTRAVEHICULAR ACTIVITY SUMMARY

Crewman	Heat load on extravehicular mobility unit, watts	
	Value range recorded	Average
Second Extravehicular Activity		
Science Pilot	123 to 776	266
Commander	128 to 310	196
Third Extravehicular Activity		
Pilot	281 to 419	357
Commander	167 to 334	223

8.3 ORTHOSTATIC COUNTERMEASURE GARMENT

The garments were donned in orbit by all crewmen, successfully pressure checked, and then depressurized prior to entry. After landing, when the Science Pilot activated his garment, a continued pressure decay was noted. Postflight analysis indicated some pressure decay from all garments, but the decay was within specification limits and no visible abnormalities were present. The decay noted by the Science Pilot was normal for this type of device. No corrective action is recommended for succeeding visits other than to advise the crew to periodically observe garment pressure and manually add pressure as required.

9.0 BIOMEDICAL

This section summarizes the medical findings of the first visit and is based on a preliminary analysis of the biomedical data.

The crew accumulated about 2018.5 man hours of space flight experience during the 28 days. The Commander and Science Pilot each accumulated approximately 4 hours and 20 minutes of extravehicular activity, and the Pilot accumulated approximately 2 hours and 10 minutes.

9.1 FLIGHT CREW HEALTH STABILIZATION

The crew health stabilization program, used on each space mission since Apollo 14, was modified to accomodate the conditions for the Skylab program. Preflight crew training was conducted at the Johnson Space Center rather than the Kennedy Space Center, and the astronauts transferred to the Kennedy Space Center two days before lift-off. Therefore, as a preventive measure to protect the crew against preflight exposure to communicable disease, proper living quarters and training areas were established at the Johnson Space Center. The number of personal contacts during the period was limited.

Surveillance of personnel requiring direct contact with the crew was conducted. Surveillance began 21 days prior to the original launch date and extended to a week beyond recovery. A modified flight crew health stabilization program at the Marshall Space Flight Center was initiated where additional training was being accomplished.

9.2 CREW MEDICAL TRAINING

The inflight medical support system provided the capability for visit completion in the event of any illness or injury that could be diagnosed and treated in flight. It also provided the capability, in case of major illness or injury, to stabilize the patient until reentry could be accomplished.

The inflight medical support system consisted of diagnostic and therapeutic equipment which the Science Pilot, a physician, and the Pilot were trained to use.

9.3 ENVIRONMENT

The Workshop atmosphere, composed of 72 percent oxygen and 28 percent nitrogen, is maintained at a total pressure of 3.45 newtons per square centimeter with a nominal oxygen partial pressure of 2.48 newtons per square centimeter and a nominal nitrogen partial pressure of 0.965 newtons per square centimeter. The environmental control system maintains these pressures and also provides for the temperature, distribution, purification, and humidification of the atmosphere.

The cabin was very quiet, and communications over any distance were somewhat difficult because of the rarified atmosphere.

The large volume of living space added to the crew's comfort. The toilet system employed was a big advancement from the previously used "baggie" method. Personal cleanliness was improved with the once a week shower.

The overall illumination was adequate in the Workshop; however, in many shadowed areas, it was necessary to use the penlight to detect details.

Items to be used by the crew for relaxation were cards, dartboards, literature and other recreational items.

9.4 CREW HEALTH

9.4.1 Preflight

The medical examinations were performed on the crewmen at specified intervals during the 40 day preflight period.

Microbiological sampling was performed 70, 40, 25, and 15 days prior to launch, and on launch day to monitor for potential inflight health problems.

The only health problem involved the Pilot and occurred 31 days before launch. The Pilot developed a short term viral gastroenteritis (inflammation of stomach and intestines) and was removed from the crew living and working areas for one day.

Drug sensitivity testing and certain allergen tests were performed. Three sleep preparations were in the medical kit. These were chloral hydrate-500 mg; sodium secobarbital-100 mg; and flurazepam hydrochloride-30 mg. Ground tests were used to determine the preferred type for each crewman.

9.4.2 Inflight

Each crewman experienced a sensation of head fullness to a varied degree after orbital insertion. The fullness was most noticeable for the first 10 to 14 days, but never fully receded. The crewmen observed facial changes in each other inflight. The facial changes were mostly a matter of muscles and associated soft tissues assuming a new position because of the lack of gravity.

A change in posture occurred as the neck muscles relaxed and the shoulder haunched up. The veins of the neck and superficial veins of the head were always full.

Motion sickness was not experienced by any of the crew after orbital insertion or during the adaptation phase of the intravehicular activities. Spatial orientation was good.

The usual working day initially averaged 16 to 18 hours. After the Workshop repairs were accomplished, the crew used planned rest and recreation days to accomplish other tasks and experiments.

The crew was awake for 22 hours the first day and this disrupted the crewmen's earth-oriented circadian rhythm. The crew began on visit day 21 to advance their bedtime and awakening each day in an attempt to reorient to the normal 24 hour physiological "body clock". Five days prior to recovery, the workday was oriented to coincide with about a 2 a.m. awakening, and about a 7 p.m. c.d.t. bedtime.

The crew noted no taste of chlorine in the command module potable water, or taste of iodine in the Workshop potable water.

All crewmen's appetites were essentially normal; however, there was a decrease in taste discrimination. No gastrointestinal distress was reported; no constipation and diarrhea occurred.

All crewmen began to notice an unexpected tingling (paresthesia) in the bottom of the feet during the last week to 10 days of flight. This tingling occurred when momentary loads were applied to the bottom of the feet.

The Science Pilot conducted general medical examinations. The only abnormal finding was the Commander's left aerotitis media, noted after the first extravehicular activity. The Commander had variable ear fullness and subjectively decreased hearing in that ear during the remainder of the flight, but the Commander did not lose the capability to valsalva.

The medical examinations showed some general reduction of muscle tonus (flaccidity) with a hyperactivity of deep tendon reflexes as compared to the preflight findings.

The Science Pilot practiced a throat culture and sensitivity procedure by obtaining a culture from the Commander.

The only medications used were Dalmane (Flurazepam), a sleeping capsule; Actifed (Triprolidine/Pseudoephedrine), a decongestant tablet; Sudafed (Pseudoephedrine), a decongestant tablet; Afrin (Oxymetazoline), nasal decongestant drops; ASA (aspirin), analgesic tablets; Synalar (fluocinolone), anti-inflammatory cream; Scopolamine-Dextroamphetamine, an anti-motion sickness capsule. Afrin was routinely used before extravehicular activity maneuvers by the crew. Sudafed and Actifed were principally utilized to control the Commander's left ear fluid accumulation. Only three Dalmane capsules were used; two of these were taken on visit day 26 to assist with the changing sleep-wake cycle. A minor headache and a contact type rash resulted in the aspirin and Synalar cream usage, respectively. One Scopolamine-Dextroamphetamine capsule was used prophylactically by the Science Pilot after orbital insertion.

Toward the latter part of the visit, the skin on the hands became dry and, in the case of the Commander and Science Pilot, scaling occurred.

9.4.3 Postflight

Prior to entry, the Commander and Science Pilot slept an estimated 4 to 5 hours and the Pilot slept only 1 hour.

After landing, when the crew were still in the couches, their pulse rates were: Commander - 84 beats per minute; Science Pilot - 84 beats per minute; and Pilot - 76 beats per minute. At separate times, with each crewman semistanding in the lower equipment bay, the pulse rates on each individual were about 96 beats per minute.

The Commander walked unassisted to the Skylab mobile laboratory. After approximately 1-1/2 hours, during which time blood drawing, microbiology testing, urine samples, and weighing were completed, the Commander resumed normal ambulation.

Fluid and air bubbles were seen behind the Commander's left tympanic membrane for about 3 days after the flight. The Commander's symptoms of occasional left ear fullness have gotten progressively better.

The Commander's postflight status was good except for some vertigo associated with head motion and this lasted one day.

After landing, the Science Pilot experienced malaise after executing postlanding tasks and drinking some strawberry drink. This condition progressed to full blown motion sickness. Approximately 25 minutes after landing and, as the Science Pilot's symptoms developed, the orthostatic countermeasure garment was inflated to approximately 2.3 newtons per square centimeter.

After the command module was taken aboard the primary recovery ship, the Science Pilot went through the opened hatch with some difficulty because of vertigo and malaise. The Science Pilot required support as he walked from the command module platform to the Skylab mobile laboratory. About 4 hours after recovery, the nausea began to abate.

The inflated orthostatic countermeasure garment produced a definite advantage. At approximately 6-1/2 hours after exiting the command module a stand test with and without the orthostatic countermeasure garment showed stabilizing cardiovascular status. The garment was removed and a lower body negative pressure test was performed. Exposure to the 0.53 newtons per square centimeter negative pressure was maintained for a shorter than normal period. Experiment M171 (Metabolic Activity), which normally follows the lower body negative pressure test, was not conducted on the Science Pilot on recovery day because of fatigue and physical unsteadiness.

The day after recovery, ambulation was nearly normal, but rapid head motion still induced stomach awareness and vertigo. Vertigo subsided by 7 days after recovery. Four days after recovery, vertigo was noted only after deliberate rapid head motions.

The Pilot's general physical condition immediately after the flight appeared to be intermediate to that of the Commander and Science Pilot. The Pilot was able to walk unassisted. Head motion also induced vertigo, but there was no associated nausea. Approximately 2-1/2 hours were needed before the Pilot could ambulate in a normal fashion.

Physical examination of the Pilot did not reveal any significant pathology.

After completing the exercise portion of the M171 experiment, the Pilot's heart rate and blood pressure dropped and the Pilot complained of nausea and dizziness. The total time from the onset of the symptoms until almost full recovery was approximately 5 minutes. Later in the afternoon of recovery day, the Pilot felt well enough to take a walk of approximately 30 minutes duration.

Postflight physical activity has been associated with varying back and lower extremity soreness for all crewmen. A return to a regular exercise program heightened these symptoms.

Preliminary analysis of the recovery day microbiological samples of the crewmen indicates no increase in the presence of medically important bacteria.

There were no significant changes in the visual function of the first visit crewmen as a result of the flight.

Postflight audiograms indicate that the Commander had a small decrease in hearing acuity in the left ear the day after recovery. The Science Pilot had a small decrease in both ears. The Pilot had no changes. Further testing will be done.

9.5 METABOLIC RATES

Physiological response of the crewmen were normal throughout the prelaunch, launch, and standup extravehicular activity phases. The heart rate range in beats per minute for the Commander was 70 to 123, the Science Pilot 82 to 115, and for the Pilot were 82 to 140. The mean respiratory rate for the three crewmen ranged between 10 and 28 respirations per minute.

The standup extravehicular activity was executed from the command module by the Pilot with the assistance of the Science Pilot. The data from this extravehicular activity are as follows.

G.m.t. (a)	Elapsed time, min	Activity completed	Metabolic rate, watts	
			Pilot	Science Pilot
146:00:12	0	First data	293	316
146:00:16	4	Trading tools	293	316
146:00:20	4	Working on strap with "pick" tool	469	293
		Average	381	305

[a]G.m.t. is shown in day of year, hours, and minutes.

The second extravehicular activity lasted 3 hours and 23 minutes. Heart rates for the Commander ranged from 66 to 138 beats per minute with the low respiratory rate being 16 respirations per minute. The heart rates for the Science Pilot ranged from 56 to 150 beats per minute with the respiration rate ranging from 12 to 35 respirations per minute. The third extravehicular activity by the Commander and the Pilot lasted 80 minutes. The Commander's heart rate ranged from 45 to 150 beats per minute with the peak heart rate noted while the solar heat shield was being adjusted. The respiration rate data were of poor quality; however, the system worked well. Tables 9-I and 9-II show metabolic rates for the second and third extravehicular activities calculated using the heart-rate method.

The average metabolic rate, using the heart rate method, was 337 watts during all the extravehicular activities. This was a little higher than the predicted.

9.6 RADIATION

The personal radiation dosimeters were worn during launch, throughout the first four days of flight, during all extravehicular activities, and during entry. During the remainder of the visit, the personal radiation dosimeters were positioned as follows: Commander - experiment compartment wall; Science Pilot - minus Z scientific airlock; and Pilot - sleep compartment.

The peak dose rates observed by the Van Allen Belt dosimeter for its Workshop location were 0.164 rad/hr at skin depth, and 0.116 rad/hr at 5 centimeters tissue depth. These values were recorded during a South Atlantic Anomaly pass. Total doses during that pass were 5.3 millirad at skin depth and 4.4 millirad at 5 centimeters skin depth. Other passes were not as high in dose rate. The data became intermittent during the latter part of the mission. See section 17.3.3.

The radiation survey meter was activated on visit day 10 for performance of a scheduled radiation survey of four locations: center sleep station; wardroom; minus Z scientific airlock; and Van Allen Belt dosimeter location. The correlation between the radiation survey meter and the Van Allen Belt dosimeter was excellent.

The electron proton spectrometer operation allowed confirmation that the electron and proton radiation environment was essentially similar to the model used in preflight projections. The electron proton spectrometer indicated a nominal radiation environment throughout its period of operation.

One passive dosimeter was worn by each crewman throughout the visit. In addition, four passive dosimeters were placed in two drawers of the Orbital Workshop film vault. The crewmen's passive dosimeters plus one passive dosimeter from each drawer were returned. The two remaining film vault passive dosimeters are scheduled for return at the end of the second visit.

TABLE 9-I.- SECOND EXTRAVEHICULAR ACTIVITY

G.m.t. (a)	Elapsed time, min	Activity completed	Metabolic rate, watts	
			Commander	Science Pilot
158:15:23	0	Depressurization		
158:15:26	3	Open hatch, Commander egress, into fixed airlock shroud	NA[a]	NA
158:15:37		Sunset		
158:14:40	14	Assembling poles and restraints	NA	NA
158:16:12	32	Planning activity in darkness	293	166
168:16:26	14	Translating to work station to deploy solar array system	367	225
158:16:40	14	Configuring poles to work the cutter	359	494
158:16:54	14	Attempting to cut strap	547	524
158:17:06	12	Commander moving out to cutter, try to cut, Commander moving back to struts for night	656	400
158:17:44	37	Resting	217	127
158:17:55	11	Sunrise, back to work configuring to cut strap	430	255
158:17:59	4	Cutting strap and pulling panel out	567	545
158:18:18	19	Disassembling poles and returning to fixed airlock shroud	424	491
158:18:25	7	Stowing gear in airlock	297	454
158:18:27	2	Science Pilot translate to VT[b]	467	415
158:18:29	2	Science Pilot observing parasol	--	284
158:18:30	1	Commander moving tree out to VT	462	--
158:18:42	12	Science Pilot work at VS[c] station	NA	NA
158:18:44	2	Science Pilot translating to fixed airlock shroud from VT	NA	NA
158:18:46	2	Ingress, close hatch, repress		
		Average	366	310

[a]G.m.t. is shown in day of year, hours, and minutes.

[b]VT - Apollo Telescope Mount sun-end transfer work station.

[c]VS - Apollo Telescope Mount sun-end work station.

TABLE 9-II.- THIRD EXTRAVEHICULAR ACTIVITY

G.m.t (a)	Elapsed time, min	Activity completed	Metabolic rate, watts	
			Commander	Pilot[b]
170:10:56	0	Depressurization		
170:11:12	16	Commander fixed charger/battery/ regulator module	365	
170:11:14	18	Extravehicular mobility unit status check	494	
170:11:38	42	VC activities[c]	328	
170:11:54	58	VT activities[d]	250	
170:12:11	75	VS activities[e]	280	
170:12:15	79	Work with heat shield material	636	
170:12:22	86	Experiment D024	425	
170:12:30	94	Ingress and repressurization	321	
		Average	329	

[a]Greenwich mean time is shown in day of year, hours and minutes.

[b]No heart rate data available on Pilot.

[c]VC - Apollo Telescope Mount center work station.

[d]VT - Apollo Telescope Mount sun-end transfer work station.

[e]VS - Apollo Telescope Mount sun-end work station.

Table 9-III indicates a preliminary estimate of total dose equivalent to the skin, lens of eye, and blood forming organs of the crewmen. These doses represent less than 10 percent of the mission guidelines, and are well below the threshold for production of detectable medical effects.

Visual flashes were once again observed by all crewmen during the visit. Bursts of light or stars were apparently more common than streaks. In some cases, the crew believed that an eye entrance and exit flash could be identified. The accumulation of these data began with Apollo and no cause for the flashes has been determined.

9.7 TOXICOLOGY

The overheating of the Orbital Workshop presented a potential toxic hazard through the expected release of toxic quantities of toluenediisocyanate, carbon monoxide, and other decomposition products resulting from thermal degradation of the polyurethane foam insulation, and through the temperature accelerated outgassing of the other spacecraft nonmetallic materials. The suitability of the atmosphere was determined from indications of toluenediisocyanate and carbon monoxide. The Orbital Workshop was purged to a dilution of approximately 12 000 to 1. Prior to crew entry, the atmosphere was verified by sampling through the pressure equalization ports. The toluenediisocyanate concentration was below the acceptable limit of 0.02 part per million, and the carbon monoxide level was 0 to 5 parts per million. On the basis of these data, the Orbital Workshop was entered and activated.

Carbon monoxide analyses on visit day 10 was determined as 10 to 15 parts per million and 7 days later, the level was reported as being below 25 parts per million. The Orbital Workshop is purged between visits to control the carbon monoxide level.

9.8 MICROBIOLOGY

Air and surface swab samples were taken on visit day 26 for postvisit analysis. Staphylococcus aureus was present in two of the 15 samples and this was the only bacteria found that was of potential concern.

The air sample count is within the range which was determined to be normal in the Skylab medical experiments altitude test. In general, there appears to be little change in the Orbital Workshop microbial load when compared to the preflight baseline.

TABLE 9-III.- DOSE EQUIVALENT VALUES

Crewman/Body area	Proton, rad	Proton, rem[a]	Electron, rad=rem[b]	Total, rem
Commander				
Skin	1.616	2.424	1.07	3.494
Lens of eye	1.616	2.262	0.107	2.369
Blood forming organs	1.066	1.276	—	1.276
Science Pilot				
Skin	1.662	2.493	0.82	3.313
Lens of eye	1.662	2.327	0.08	2.407
Blood forming organs	1.097	1.313	—	1.313
Pilot				
Skin	1.805	2.708	0.25	2.958
Lens of eye	1.805	2.527	0.03	2.557
Blood forming organs	1.191	1.426	—	1.426

[a]Proton rem = rad (quality factor)

Quality factor = 1.5 for skin
Quality factor = 1.4 for eyes
Quality factor = 1.2 for blood forming organs.

[b]Electron quality factor = 1.0

SECTION 10.0 WILL BE FURNISHED AT A LATER DATE.

11.0 GENERAL PHOTOGRAPHY AND CAMERA SYSTEMS

11.1 SUMMARY

General photographic systems were utilized on the first visit to document the following:

a. The exterior damage to the Orbital Workshop, for future analysis.

b. The flyaround inspection of the Saturn Workshop.

c. The docking dynamics of the command and service modules.

d. General Orbital Workshop operations.

e. Targets of interest on the earth.

f. Workshop closeout configuration.

g. Anomalous conditions experienced during the visit.

h. Results of experiments conducted on this visit.

The general photographic systems included a 35 mm camera, a 70 mm data camera, a 16 mm data acquisition camera, and a 127 mm earth terrain camera. Basic descriptions of these systems are contained in Appendix A of this report with further details contained in Reference 4. All systems operated normally with only minor exceptions. Scheduled photographic objectives were met and the photographic quality was good.

11.2 DATA ACQUISITION CAMERA (16 MM) SYSTEM

The 16 mm camera systems were used during the visit to record command module maneuvers around the Saturn Workshop, the Orbital Workshop damage inspection, and the performance of many experiments.

11.2.1 Usage

Table 11-I lists the 16 mm camera usage for all visit. Approximately 90 percent of the scheduled usage of the 16 mm data acquisition camera was achieved during the first visit. The remaining 10 percent was not completed because of time limitations. The three magazines scheduled for

TABLE 11-I.- PLANNED 16-mm CAMERA USAGE

Experiment/ activity	Experiment/Activity Title
D021	Expandable Airlock
ED52	Spider Web Formation
ED63	Cytoplasmic Streaming
ED72	Capillary Studies
ED74	Mass Measurement
ED78	Liquid Motion
M092	Lower Body Negative Pressure
M093	Vectorcardiogram
M110	Blood Sampling
M131	Human Vestibular Function
M151	Time and Motion Study
M171	Metabolic Activity
M479	Zero Gravity Flammability
M487	Habitability/Crew Quarters
M509	Astronaut Maneuvering Equipment
M512	Materials Processing in Space
M516	Crew Activities/Maintenance Study
M551	Metals Melting
M553	Sphere Forming in Space
S019	Ultraviolet Stellar Astronomy
S020	X-Ray Ultraviolet Solar Photography
S073	Gegenschein/Zodiacal Light
S149	Particle Collection
S183	Ultraviolet Panorama
S191	Earth Resources Experiment Package - Infrared Spectrometer
T013	Crew Vehicle Distrubances
T020	Foot Controlled Maneuvering Unit
T027	Contamination Measurement
EVA	Extravehicular Activity
Operational	Flyaround Activity, Vehicle Inspection, and Interior Crew Activities

use in the command module were exposed. A review of these magazines indicates that the exposures were correct, except for the underexposed parachute sequence on earth landing.

All interior Workshop photography was satisfactory except for film which was underexposed due to low light levels when the vehicle power was in a critical state. Some of the 5 mm lens photography was slightly out of focus. All experiment photography was normal. Approximately 244 meters of film was used in documenting crew operations, not including experiment set up activities. Crew operations photography is excellent and should enhance the training of the second and third visit crews.

11.2.2 Hardware Performance

Equipment performance was satisfactory; however, the Orbital Workshop thermal problem subjected the 16 mm film to temperatures in excess of 322° K. The highest estimated temperature was 325° K, well in excess of the desired 300° K temperature. The high temperature curled the leading footage of each 122 meter canister roll and resulted in a crew procedure change which required the crew to strip 2 meters of film (demonstrated by ground tests to be unusable) from each 122 meter canister prior to use. This resulted in a loss of sensitometry on all 122 meter canisters of 16 mm S0168 film. Prior to receiving this procedure, threading of the film was difficult. Some film jams occurred on the 16 mm system, and each was cleared using the onboard procedures. One untouched roll of 122 meter film was returned for analysis and test. Physical tests with the transporter and camera revealed a slight stickiness (film sticking to itself). The stickiness was insufficient to warrant a resupply of film to the Orbital Workshop for the second visit. The four surplus 122 meter canisters were transferred to a lower film vault drawer at the end of the first visit for radiation protection. Six of the eleven 16 mm cameras on board were used for an approximate total operating time of 14 hours.

11.3 35-MM CAMERA SYSTEM

The 35 mm camera system was used to record data for damage assessment, student experiments, and operational photography. In addition, the crew removed the electric camera body from the experiment S063 container and used the camera with the 300 mm lens for air-to-ground photography of targets of interest. All other equipment was used as planned.

11.3.1 Usage

Use of the various magazines and the activities photographed are shown in the following table.

Magazine[a]	Film type	ASA rating	Subject/Activities
CI26	S0168	500	Interior with flash
CI27	S0168	160	Exterior
CI28	S0168	500	Interior with flash
CI29	S0168	160	Exterior
CI30	S0168	160	Exterior
CI31	S0168	500	Interior with flash (day 167)
CI32	S0168	160	Exterior
CI33	S0168	500	Interior with flash
CI34	S0168	160	Exterior
CI35	S0168	160	Exterior (day 161)
CX21	S0368	64	Damage assessment
CX22	S0368	64	Exterior
BW07	3400	80	Not used (left in Orbital Workshop)

[a]CI designation preceding magazine number indicates interior color film, CX indicates exterior color film, and BW indicates black and white film.

11.3.2 Hardware Performance

The 35 mm camera system operation was normal except for one minor problem with the counter. The counter on the 35 mm electric camera stopped counting the first time the camera was used. Further discussion of this anomaly is contained in section 17.3.7.

Flight film results indicate that the system functioned as expected in documenting several inflight anomalies of other systems. The electronic flash greatly enhanced the interior photography. The closeout photography using the electronic flash is of particular value in establishing the Orbital Workshop condition at the end of the first visit. Figure 11-1 is a photograph showing partial deployment of the wing 1

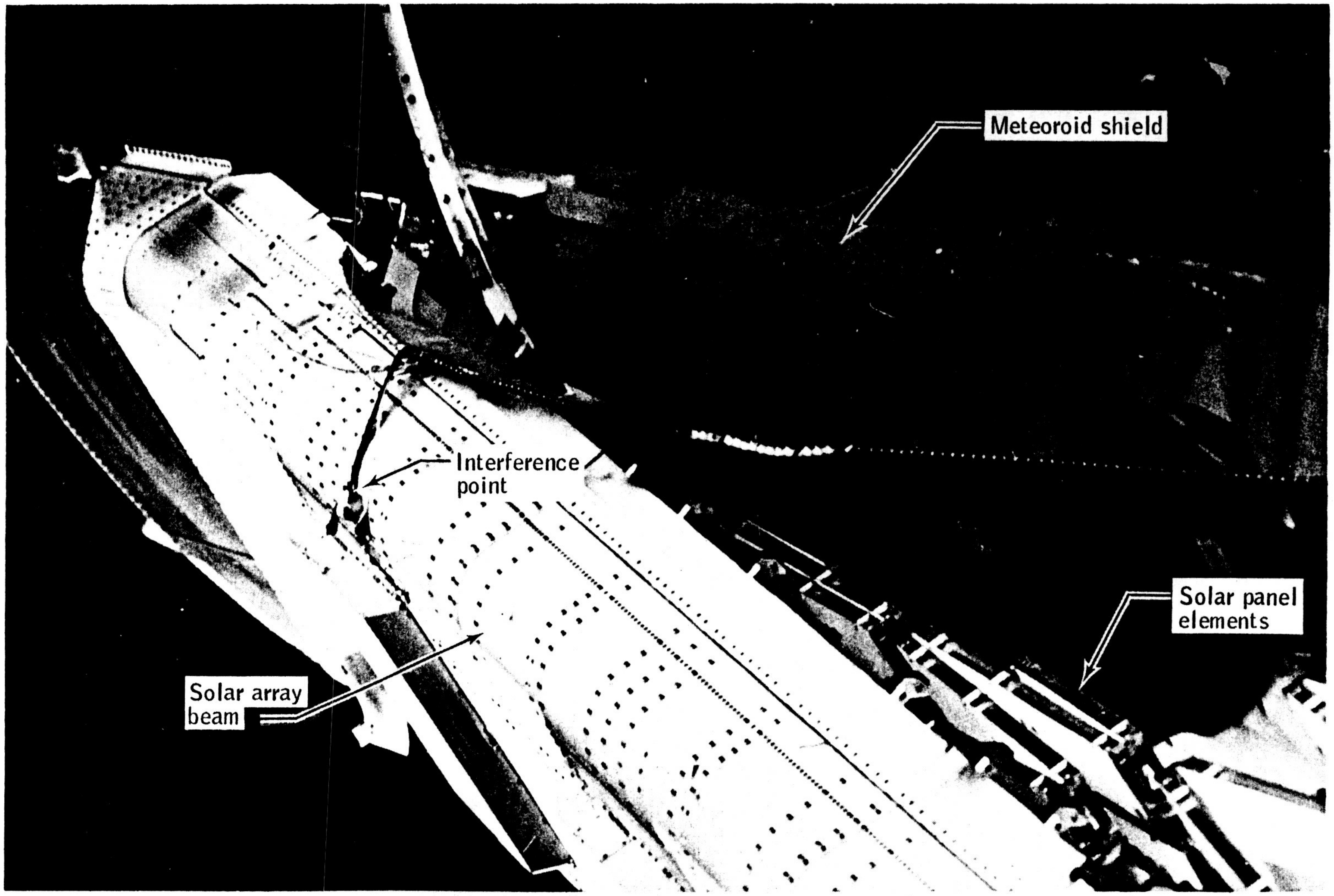


Figure 11-1.- Solar array wing hangup during initial flyaround with 35 mm camera and 300 mm lens.

beam. The picture was taken with the 300 mm lens on the 35 mm camera and was made during the flyaround inspection of the Saturn Workshop. Figure 11-2 is a typical picture of the interior operational documentation photography obtained using an electronic flash unit.

11.4 DATA CAMERA (70 MM) SYSTEM

The 70 mm data camera system was used for operational photography of the Saturn Workshop exterior during approach, docking, and the flyaround for damage assessment, and for general and scientific interest photography of the earth from inside the Orbital Workshop.

11.4.1 Usage

The camera stowed in the command module was used for all photography. Two film magazines were used exclusively for earth terrain and weather photography. One magazine was used for recording data for the damage assessment at the beginning of the visit, and one was used during the flyaround inspection. The following table shows the system usage for the first visit.

Magazine[a]	Frames used	Earth views	Vehicle views
CX04	72	21	47
CX05	162	159	
CX06	113	110	0
CX23	106	16	89

[a]CX designation preceding magazine number indicates S0368 exterior color film.

Figure 11-2.- Typical 35 mm camera documentation.

11.4.2 Hardware Performance

The 70 mm data camera system performed normally except that magazine CX04 did not remain synchronized (red flag on magazine indicator), causing the camera system to stop operating, and film magazine CX05 failed to count. See sections 17.3.1 and 17.3.2 for additional information on these anomalies. No photographic data were lost because of the anomalous conditions.

Figures 11-3 and 11-4 are examples of 70 mm photography. Figure 11-3 is a picture of the Saturn Workshop showing the configuration prior to command and service module docking. Figure 11-4 shows the Saturn Workshop configuration after extension of the wing 1 solar arrays and deployment of the Skylab parasol.

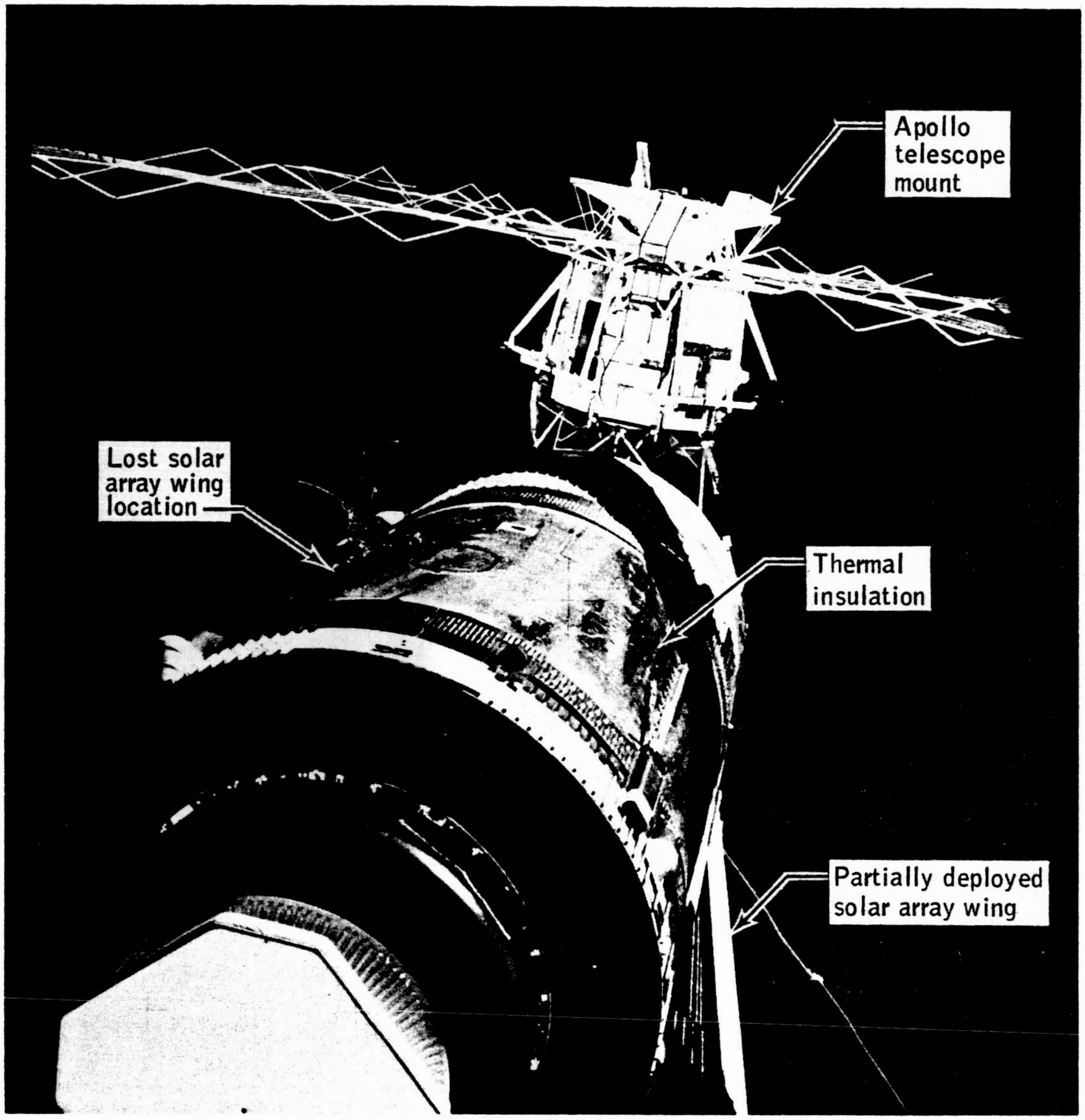


Figure 11-3.- Saturn workshop prior to docking.

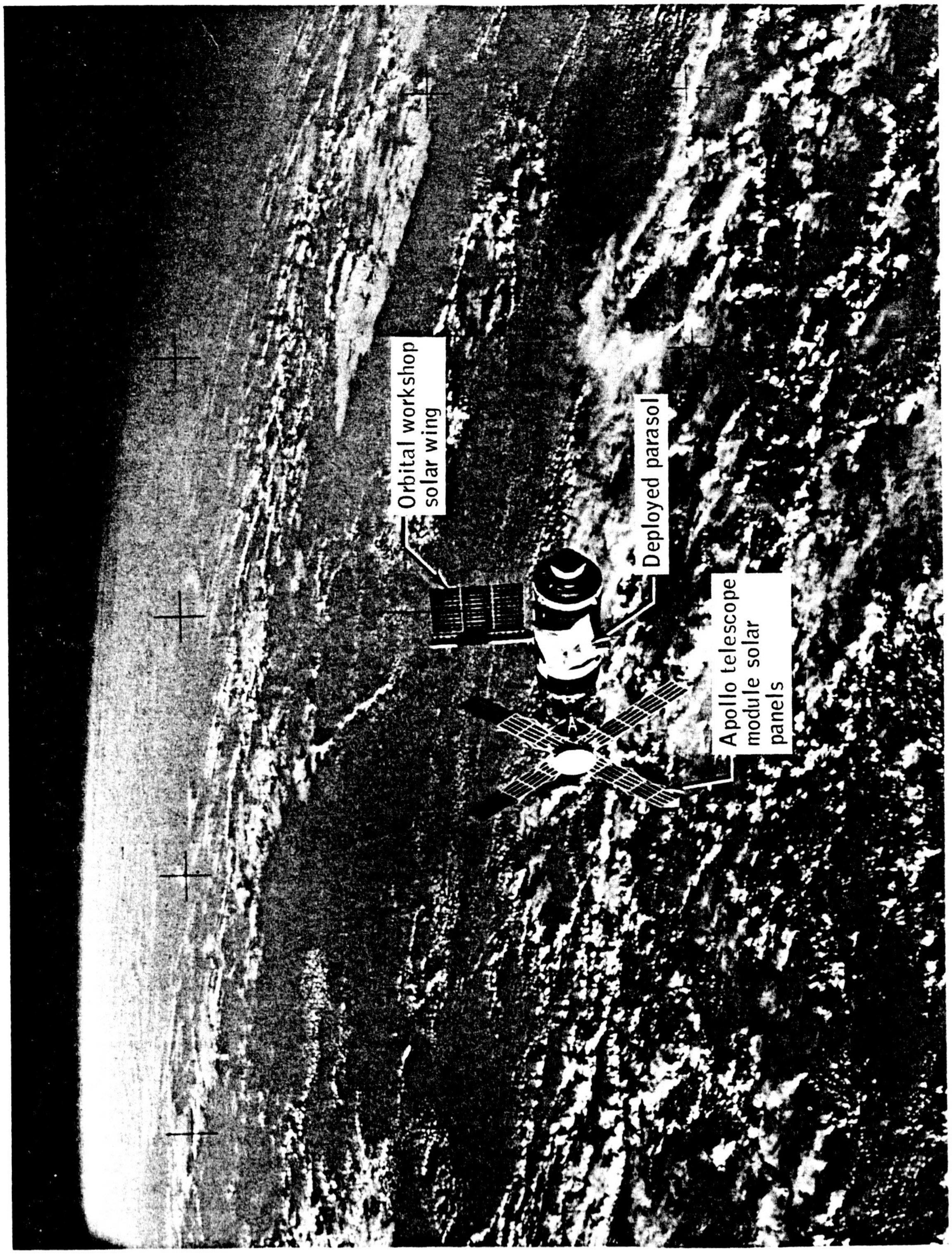


Figure 11-4.- Saturn workshop during final flyaround inspection.

12.0 TRAJECTORY

Lift-off of the first Skylab visit occurred at 13:00:00.8 G.m.t. (09:00:00.8 a.m. e.d.t.) on May 25, 1973, (visit day 1) from Launch Complex 39B with earth orbital insertion occurring 9 minutes and 56 seconds later. As a result of the Orbital Workshop problems, the first visit was launched 10 days later than planned, and this delay required that several changes be made to maximize spaceflight tracking and data network coverage for a flyaround inspection of the workshop with television coverage. These changes include:

a. Insertion into an orbit with an apogee of 352 kilometers instead of 222 kilometers. This orbital insertion permitted a lift-off near the zero yaw steering point, while still maintaining the rendezvous in the fifth orbit.

b. The nominal terminal phase initiation maneuver was moved forward 5 minutes, and the tolerance for performing the maneuver was changed to ±5 minutes, instead of ±10 minutes.

c. A rendezvous during orbits 6, 7, and 8 was not considered because of the severe limitations on television coverage and passes over the continental United States after rendezvous. Television coverage was desired to determine the exterior condition of the Orbital Workshop.

d. The Z axis local vertical rendezvous maneuver for the Saturn Workshop was eliminated because of thermal and electrical power system attitude constraints. The elimination of this maneuver was expected to eliminate sextant tracking prior to the second phasing maneuver, eliminate part of the sextant tracking prior to the coelliptic maneuver, and eliminate on board chart solutions for the corrective combination, coelliptic, and terminal phase initiation maneuvers.

Table 12-I presents a comparison of the prelaunch rendezvous profile with the actual rendezvous profile and table 12-II presents the midcourse maneuvers.

The ground and onboard solutions (table 12-II) agreed within the comparison limits of 0.3 meters per second, 0.9 meters per second, and 0.9 meters per second in the X, Y, and Z axes, respectively. Consequently, the onboard solutions were used for maneuver execution. The magnitude of the second midcourse correction solution was approximately a 2-sigma solution when compared to the preflight analyses, and was probably the result of errors in the first midcourse correction.

The changes made in the rendezvous profile were executed with no major problems. Most of the estimated errors fell within the ±2 sigma

TABLE 12-I.- RENDEZVOUS SUMMARY

Event	Preflight profile			Real time profile		
	Time, G.m.t.	Differential velocity, meters/second	Altitude, kilometers	Time, G.m.t.	Differential velocity, meters/second	Altitude, kilometers
Lift-off	13:00:00	--	--	13:00:00.4	--	--
Insertion	13:09:55	--	354/156	13:09:56	--	357/156
S-IVB/spacecraft separation	13:16:00	0.91	--	13:16:00	1.03	--
First phasing maneuver	15:23:36	66.4	383/354	15:23:38	62.8	372/359
Second phasing maneuver	17:41:23	14.3	404/383	17:41:20	13.1	406/389
Corrective combination maneuver	18:27:32	8.2	4.5/406	18:27:27	12.2	4.7/404
Coelliptic maneuver	19:04:32	5.8	424/415	19:04:27	7.9	424/415

TABLE 12-II.- FIRST VISIT TERMINAL PHASE RENDEZVOUS SOLUTIONS AND MANEUVERS

Terminal Phase Initiation Maneuver		
Event/axis	Ground solution	Onboard solution
Time, hr:min:sec	20:03:50	20:03:48
X axis, meters/sec	5.6	5.5
Y axis, meters/sec	0.4	0.2
Z axis, meters/sec	-2.2	-2.4
Midcourse Maneuvers		
Axis	First midcourse correction	Second midcourse correction
X axis, meters/sec	0.15	-1.4
Y axis, meters/sec	0	-0.24
Z axis, meters/sec	0.06	-0.24

range, indicating satisfactory systems performance, and lending confidence to the premission rendezvous analysis. Other items which should be noted with regard to the total rendezvous performance are:

a. The Spaceflight Tracking and Data Network performance was below expectations in that data from several passes were poor and other data were unusable. (Section 13.2 discusses the network performance in more detail.)

b. Lock-on and maintaining it with the sextant and VHF were considerably better than preflight estimates.

As a result of the 1.5 meters per second insertion error (overfiring) and the 10-day launch delay of first visit, the preflight determined repeating ground track was approximately 92.6 kilometers east of the actual ground track. Because of the large differential velocity required to return to the preflight planned ground track, the first orbital trim maneuver was planned to maintain the current ground track (approximatel 92.6 kilometers west of nominal) and return to the preflight planned ground track on the third visit. The resulting trim maneuvers made to maintain the ground track are shown in table 12-III. The purpose of these trim maneuvers was to maintain an orbital period which would result in any given track passing over the same ground point every 5 days. Because of the insertion overfiring, the ground track was drifting to the west about 7.4 kilometers per day. Fixing the ground track to become repeating and, therefore, stopping the drift caused the first trim maneuver to be performed in the retrograde attitude at orbit noon. The maneuver was targeted to minimize the correction on the second visit, if for some reason the second trim maneuver could not be made.

The repeating ground track concept was included in Skylab to enhance the Earth Resources Experiment Package data collection. This concept provides the Earth Resources Experiment Package planners with a valuable tool for long-range planning when the same task sites are covered every 5 days (approximately 2 hours earlier on each repeat). The setting of the first visit ground track to where it repeats approximately 92.6 kilometers west of the planned track degraded the flight estimate of site coverage; however, considering the alternative of doing nothing until the second visit, the repeat that was obtained was acceptable. Tables 12-IV and 12-V present a comparison of the preflight Earth Resources Experiment Package passes with the first visit real-time selected passes.

The undocking, flyaround inspection, deorbit maneuvers, and entry sequence were constrained by the requirements to obtain television coverage of the flyaround inspection, and recover the crew and spacecraft in daylight with adequate recovery support. These requirements resulted in a descending west coast entry landing at 127.04 degrees west longitude

TABLE 12-III.- ORBITAL TRIM MANEUVERS

Event	Time, G.m.t.	Revolution	Differential velocity, meters/sec	Firing time, sec	Propellant used, kilograms
First trim maneuver	149:01:07:36	206	0.63	63	20.9
Second trim maneuver	168:13:30:52	489	0.91	9	2.8

TABLE 12-IV.- PREFLIGHT EARTH RESOURCES EXPERIMENTS PACKAGE PASS SUMMARY

Pass number	Track number	Revolution number	Day	Time, G.m.t.	
				Start	Stop
1	1	72/3	139	17:08:57	17:33:57
2	16	87/8	140	18:00:31	18:25:31
3	30	101/2	141	17:17:00	17:33:00
4	58	129/0	143	15:48:54	16:13:54
5	15	157/8	145	14:27:14	14:52:14
6	29	171/2	146	13:42:38	14:07:48
7	43	185/6	147	12:39:37	13:10:47
8	63	205/6	148	21:37:00	22:04:20
9	34	247/8	151	19:48:52	20:13:52
10	48	261/2	152	19:06:01	19:31:01
11	61	274/5	153	16:33:28	16:58:28
12	62	275/6	153	18:22:11	18:50:45
13	19	303/4	155	16:57:47	17:23:36
14	6	361/2	159	17:17:14	17:44:44

TABLE 12-V.- REAL-TIME EARTH RESOURCES EXPERIMENTS PACKAGE PASS SUMMARY

Pass number	Track number	Revolution number	Day	Time, G.m.t.		Longitude and latitude, deg	
				Start	Stop	Start	Stop
1	20	233/4	150	20:34:00	21:01:00	145 W, 49 N	63 W, 17.8 S
2	63	276	153	20:04:00	20:14:00	133 W, 43 N	100 W, 18.4 S
3	6	290	154	19:22:00	19:33:00	128 W, 40 N	92 W, 14 N
4	19	303/4	155	17:05:00	17:17:00	103 W, 44 N	64.5 W, 15 N
5	34	318	156	17:57:00	18:09:00	117 W, 42 N	80.3 W, 11 N
Special		333	157	18:55:00	19:01:00	111 W, 24 N	96 W, 7.2 N
6	19	374/5	160	15:02:00	15:28:00	122 W, 49 N	41 W, 15.5 N
7	33	388/9	161	14:19:00	14:46:00	120 W, 49 N	35 W, 17 S
8	48	403/4	162	15:12:00	15:40:00	127 W, 47 N	45 W, 26 S
9	61	416/7	163	12:56:00	13:20:00	100 W, 48 N	28 W, 14 S
10	5	431/2	164	13:42:00	14:14:00	112 W, 46 N	48 W, 32 S
11	20	446/7	165	14:40:00	15:08:00	125 W, 44 N	48 W, 32 S

and 24.46 degrees north latitude. Table 12-VI presents a comparison of the preflight deorbit and entry profiles with the actual deorbit and entry profile.

TABLE 12-VI.- FIRST VISIT DEORBIT PROFILE

Event	Preflight profile			Real time profile		
	Time, G.m.t.	Differential velocity, meters/sec	Perigee altitude, kilometers	Time, G.m.t.	Differential velocity, meters/sec	Perigee altitude, kilometers
Undocking	8:44:12	—	—	8:55	—	—
Separation	9:44:12	1.5	—	9:40:00	1.5	—
First deorbit maneuver	10:05:25	81:4	167.4	10:05:29	80.5	167.4
Second deorbit maneuver	13:10:41	57.9	-17.2	13:10:46	57.9	-16.5
Entry (400 000 ft altitude)	13:33:39	—	—	13:33:48	—	—
Landing	13:49:48	—	—	13:49:49	—	—

13.0 MISSION SUPPORT

13.1 FLIGHT CONTROL

The loss of the meteroid shield and the failure of the Orbital Workshop solar array system wings to deploy increased the difficulty in managing the Orbital Workshop systems, as well as causing a 10 day delay of the first visit. In this interim, the proficiency in operating the Mission Control Center data retrieval system and in managing the various spacecraft systems prior to crew arrival at the spacecraft was significantly enhanced.

The difficulties involved in the initial unmanned operation primarily arose from the thermal characteristics of the Orbital Workshop with the meteroid shield missing, and the requirement to maintain adequate power generation capability. Some systems tended to get very warm, and when the Skylab was placed in an attitude to reduce temperatures in these areas, other portions of the vehicle became too cold. An attitude consisting of a pitch of approximately 3/4 of a radian evolved as a best compromise for the various systems. Unfortunately, there were no attitude pointing and control system attitude references for this thermal attitude. The method adopted to evaluate the attitude was based on:

a. The use of structural temperatures on either side of the vehicle to provide a zero-degree roll.

b. The use of momentum buildup in the Z axis to evaluate the position of the Z principal axis with respect to the orbital plan.

c. Evaluation of the power output from the Apollo Telescope Mount solar array to determine the pitch attitude.

The proficiency of evaluating the overall attitude and conducting the small maneuvers required to maintain the spacecraft in the correct thermal attitude improved as the unmanned period progressed. There were situations, however, that required large maneuvers, i.e., maneuvers of about 1/3 of a radian or greater. Invariably, the attitude resulting from these large maneuvers was considerably different from that desired and commanded through the Apollo Telescope Mount digital computer. Subsequent evaluation during the first visit indicated that a combination of gyro drift, scale factor changes, intermittent discrepancies in the gyro performance, and possible logic discrepancies when the gyros switched from fine gain to course gain all combined to cause dispersions in the large maneuvers. These characteristics of the attitude pointing and control system compounded the task, although, the necessary attitude maneuvers were eventually accomplished. In many cases, however, excessive thruster attitude control system impulse usage was required due to the unexpected response of the vehicle.

The manned operations were initially characterized by requirements to conserve electrical power. This required the flight planning operation to be highly flexible. The activation sequence was extended because of required configuration changes as well as for the requirement to extend the parasol device. Operations were also constrained by the crew having to spend extra time in the command module while the Workshop was cooling down.

The basic prelaunch flight control activities schedule was used after the activation sequence. This proved to be effective and will require only slight modifications for subsequent visits. One exception was made because of the critical aspects of the electrical power system. This exception was to generate a summary flight plan 2 days in advance, instead of the originally planned 1 day. Each day, a detailed evaluation was made of the electrical power profile to control the depth of discharge of the Apollo Telescope Mount batteries. In most cases, the desired experiments could be conducted; however, adjustments were invariably required in some portion of the daily flight plan. These frequently included powering down some spacecraft systems such as wall heaters, hot water heaters, food warming trays, etc. In addition, adjusting the sequence of experiments was frequently necessary so that a daylight cycle existed between experiment protocols requiring high power levels so that the Apollo Telescope Mount batteries could recover. As the electrical power system responses became better known and as the actual power usage of the various experiment modes was demonstrated, operational constraints were adjusted to allow increased experiment operations. This was particularly true in the case of the Earth Resources Experiment Package where the original constraints were relaxed and better opportunities for data acquisition became available.

The extravehicular activity to deploy the solar array system wing was successfully conducted even though there were problems with the extravehicular activity life support cooling system. These problems were overcome in real time, and deployment of this wing alleviated the power constraints for this visit. After wing deployment, the experiment operations were continuing with no operational constraints. However, some non-essential equipment power down was still required.

The latter phase of the visit was characterized by several unexpected thruster attitude control system firings that were caused by maneuver time errors, buildup of undersirable momentum due to propulsive vents, and successive momentum dump inhibits required by some of the experiments.

The crew's proficiency was noticeably improved in conducting all of the experiments by the last third of the visit. As a result, several of the lower priority tasks were performed and, consequently, a high percentage of the original Skylab experiment operations was accomplished.

Experiment deactivation and entry preparation was conducted according to the preflight plan. The entry simulation was conducted and proved to be an inefficient use of both the crew time and flight control time. This aspect of the first visit will be evaluated and different techniques adopted for second and third visits. Considering the many configuration changes, the actual checklist changes were minimal. The ground tracking and maneuver calculations were all accomplished according to the preflight plan and the entry was normal.

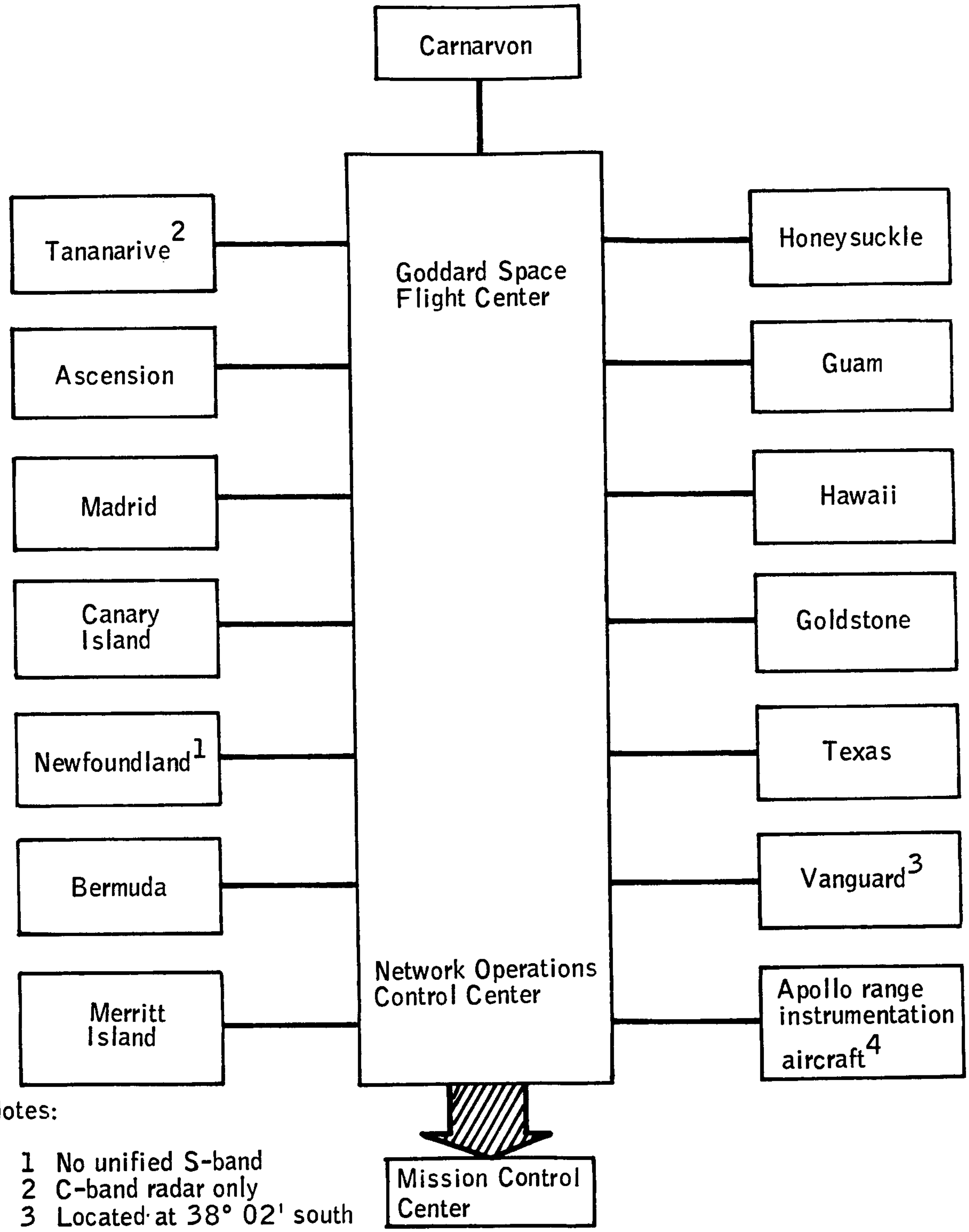
13.2 SPACEFLIGHT TRACKING AND DATA NETWORK

The Spaceflight Tracking and Data Network (fig. 13-1) support of the first visit was satisfactory. The hardware, software and personnel performance were each very good with minor exceptions. Some hardware failures, software problems, and personnel procedural problems were experienced, but the collective impact on the visit support was minor. The most significant impact was delays in the final processing of selected experiments data. Data quality was poor on some passes. Two factors contributing to the poor quality dara are: multipath signals on VHF at low elevation angles and ignition noise from harbor vehicles near the range station ship Vanguard.

The quantity of data was greater than expected, resulting in a system overload between the Spaceflight Tracking and Data Network and Mission Control Center. Software problems in the Real Time Computer Complex resulted in application downtimes that further complicated retrieval of data from the Spaceflight Tracking and Data Network. Also, problems were experienced in processing some experiments data within the Real Time Computer Complex which contributed to delays in data delivery.

Station capabilities generally included unified S-band, VHF telemetry, UHF command, VHF voice, and data processing. Communications to each site included four 7.2 kilobits per second data circuits, two voice circuits, and two teletype circuits. Television circuits were utilized at Guam, Goldstone, Texas, and Merritt Island, on an as required basis for relaying television transmissions to the Mission Control Center. C-band radar at Canarvon, Merritt Island, Bermuda, and Tananarive were used for orbit determination of the unmanned Orbital Workshop.

The most significant change to the Spaceflight Tracking and Data Network between Apollo and Skylab was in the techniques of processing telemetry data. During Apollo, fixed formats of selected data at reduced sampling rates were used for transmission of telemetry data to the Mission Control Center for mission operations. Detailed postflight engineering analysis and experiment data reduction was accomplished using magnetic tape recordings of telemetry data shipped from each site to the Johnson Space Center.



Notes:

1 No unified S-band
2 C-band radar only
3 Located at 38° 02' south and 57° 32' west
4 With Apollo capabilities

Figure 13-1. - Spaceflight tracking and data network.

For Skylab, techniques of redundant sample removal were used to reduce the telemetry data volume at each site such that all the intelligence in the data could be transmitted over the data circuits to the Mission Con-Control Center. Telemetry links containing operational data were processed in real time to the Mission Control Center. After the pass, all links were processed at the remote site into an all digital data tape for transmission to the Mission Control Center at data rates compatible with communication circuit capabilities. The transmitted all digital data tape data was used for detailed engineering analysis and experiment data reduction. These techniques provided early access to all telemetry data and reduced the need for shipping most of the magnetic tapes to the Johnson Space Center.

Command data processing for Skylab was very similar to Apollo. The one major change for Skylab was the utilization of UHF transmitters from Gemini and early Apollo flights for commands to the Orbital Workshop. One computer was utilized at each site for command processing. Real time commands were stored in the computer for uplink in response to the Mission Control Center execute commands. Teleprinter and computer load commands were formatted at the Mission Control Center, transmitted to appropriate sites, sorted in the computer temporarily and uplinked in response to the Mission Control Center execute commands. Commands were uplinked either through the unified S-band or UHF systems depending upon whether the command was being sent to the command and service module or the Orbital Workshop.

The processing of tracking data was also very similar to that used on the Apollo program. The unified S-band data were the primary data source except during unmanned Workshop periods when the C-band radar skin track data were utilized. High speed (10 samples every second) data from Merrit Island and Bermuda were used during launch and low speed (one sample every 6 seconds) data were utilized for orbital ephemeris determinations.

Real time voice communications with the crew were the same as Apollo. Crew voice recorded onboard the command and service module or Orbital Workshop was subsequently downlinked to a network site where the voice was played back on a delayed basis and transmitted to the Mission Control Center over voice circuits.

The television recording capability was used at all sites with unified S-band systems, plus the capability to remote television to the Mission Control Center was provided from Guam, Goldstone, Texas, and Merritt Island. The Goldstone, Texas, and Merritt Island capabilities were utilized on a daily basis for real time and playback to the Mission Control Center of television previously recorded at those sites. Recordings of television from other sites were shipped to the Johnson Space Center.

13.3 RECOVERY OPERATIONS

The Department of Defense provided recovery support. The recovery force deployment is outlined in table 13-I.

13.3.1 Prelaunch Through Orbital Insertion

Twenty four hours prior to the launch for the first visit, the Department of Defense recovery forces reported under the command of the Department of Defense Manager for Manned Space Flight Support. After orbital insertion, the recovery forces were released or placed on alert, as appropriate.

13.3.2 Orbital Operations

The primary recovery support from orbital insertion to recovery minus 6 days consisted of helicopters and HC-130 aircraft at Hickam AFB, Hawaii, and an on-call duty salvage ship at Pearl Harbor, Hawaii. This support posture was developed as the result of medical requirements and the capability to land the command module near the Hawaiian Islands at least once a day. Also, the capability existed to fly the Skylab mobile laboratory from the Johnson Space Center to Hawaii on a C-5 aircraft and have the laboratory operationally ready to receive the crew after landing.

In addition to the support in Hawaii, air rescue units at various air rescue bases around the world were prepared to provide support should a contingency landing occur.

13.3.3 Primary Landing Area Support

Recovery support for the primary landing area in the Eastern Pacific Ocean was provided by the USS Ticonderoga. Air support consisted of four SH-3G helicopters and one E-1B aircraft from the USS Ticonderoga and two HC-130 rescue aircraft staged from Hamilton AFB, California. Figure 13-2 shows the relative positions of the recovery ship and its aircraft, and the HC-130 aircraft prior to landing. The figure also shows the target point, the crew readout of the computer landing point (while on main parachutes), and the estimated landing point.

TABLE 13-I.- FIRST VISIT RECOVERY SUPPORT

Type ship/ type aircraft	Number	Ship name/aircraft staging base	Responsibility
ARS	1	USS Escape	Launch site recovery ship and sonic boom measurement platform.
ARS	1	USS Grapple	Duty salvage ship providing secondary landing area support.
CVS	1	USS Ticonderoga	Primary recovery ship.
HH-53C	2	Patrick Air Force Base	Launch site area.
HC-130	2[a]	Pease Air Force Base	Launch abort area in west- and mid-Atlantic areas.
	1[a]	Pease Air Force Base	Contingency support—in west Atlantic sector.
HH-3E	1[a]	Loring Air Force Base	Minimum crew retrieval time during launch in west-Atlantic area.
HH-3E	1[a]	Gander International, Newfoundland	Minimum crew retrieval time during launch in west- and mid-Atlantic areas.
HC-130	1	RAF Woodbridge, England	Support for launch aborts in mid- and east-Atlantic areas.
HC-130	1[a]	RAF Woodbridge, England	Contingency support in east-Atlantic sector.
HC-53C	1	RAF Woodbridge, England	Minimum retrieval times for aborts in east-Atlantic sector.
HC-130	1[a]	Hickam Air Force Base	Recovery support for target points in secondary landing area.
HH-53C	2[a]	Hickam Air Force Base	Secondary landing area support for orbits after docking.
HC-130	1[a]	Hamilton Air Force Base	Recovery support in east-Pacific sector.
HC-130	2	Hamilton Air Force Base	End-of-mission recovery support for landings uprange and downrange of target point.
HC-130	1[a]	Eglin Air Force Base	Contingency support in west-Atlantic sector.
HC-130	1[a]	Kadena Air Force Base, Okinawa	Contingency support in west-Pacific sector.
HC-130	1[a]	Clark Air Force Base, Phillippines	Contingency support in west-Pacific sector.
SH-3G El B relay	4 1	USS Ticonderoga	Support in primary end-of-mission landing area.

[a]On air rescue and recovery service alert and configured with Skylab recovery equipment.

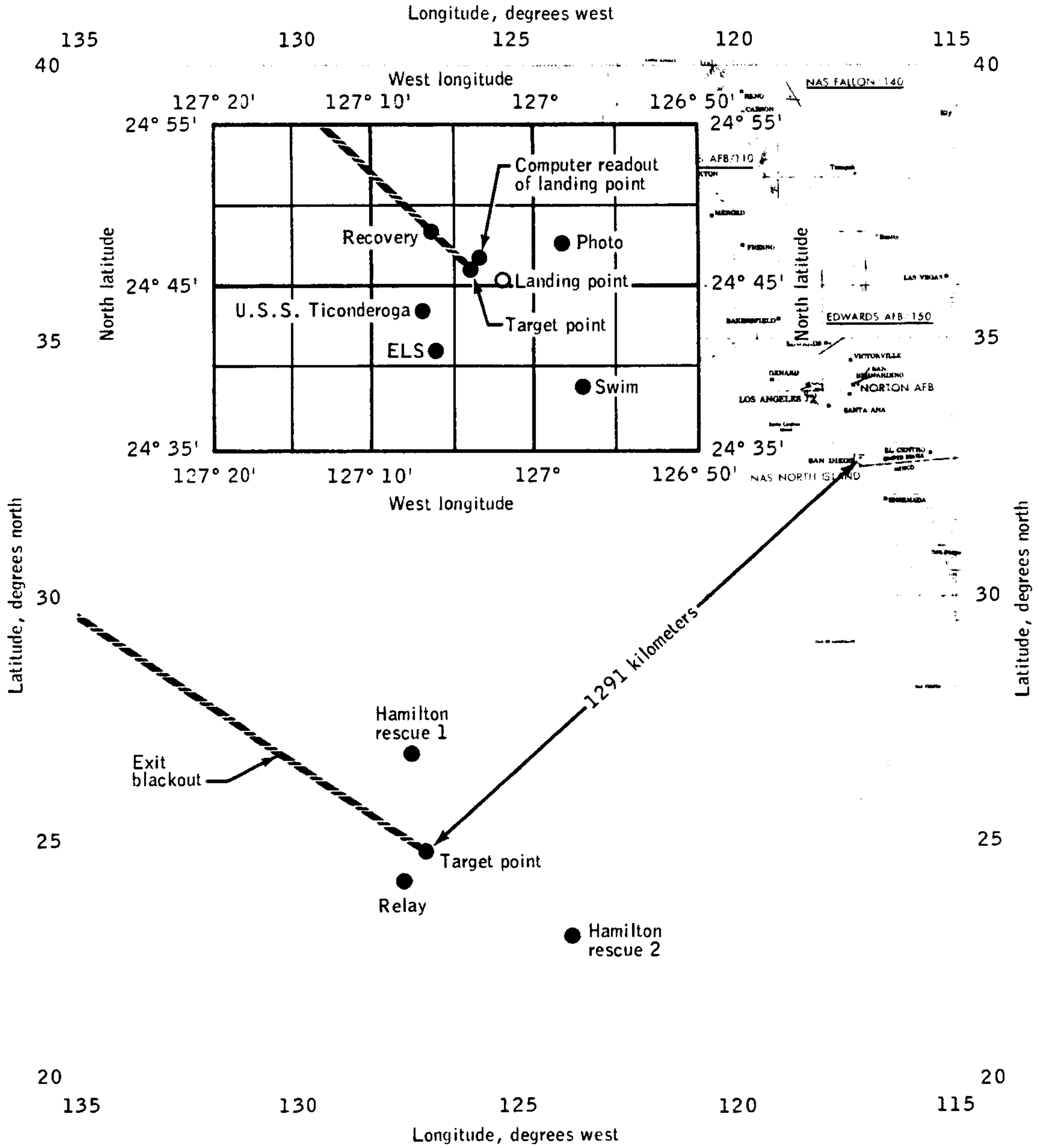


Figure 13-2.- Recovery forces deployment.

13.3.4 Command Module Location and Retrieval

Table 13-II is a chronological listing of the events of recovery and post-recovery operations.

Weather on recovery day was good. At landing, the cloud coverage was 90 percent at 550 meters and winds were 2.6 meters per second from northeast. The water condition was 0.3 meter seas on top of 1.2 meter swells. The air temperature was 291° K and the water temperature was 293° K.

Radar contact with the command module was reported by the USS Ticonderoga at 13:40:30 G.m.t., on June 22, 1973 (visit day 29). The command module landed at 13:49:48 G.m.t. Using the ship's position, plus visual bearings and radar ranges, the landing point coordinates of command module were determined to be 24 degrees 45 minutes 18 seconds north latitude, 127 degrees 2 minutes west longitude.

The command module landed in the stable 1 attitude. The command module was retrieved with the crew inside and the crew were aboard the recovery ship 40 minutes after landing. The crew egressed from the command module and walked to the Skylab mobile laboratory. After recovery, reefing lines from the drogue parachute were found on one of the helicopter landing gear struts. A discussion of this anomaly is contained in section 17.1.9.

TABLE 13-II.- RECOVERY EVENT TIMELINE

Event	Time, G.m.t.	Time relative to landing, day:hr:min
	June 22, 1973 (visit day 29)	
Radar contact by Ticonderoga	13:40	-0:00:09
VHF recovery beacon contact	13:45	-0:00:04
Visual contact with command module	13:45	-0:00;04
VHF voice contact	13:46	-0:00:03
Command module landing	13:49:49	0:00:00
Flotation collar inflated	13:57	0:00:07
Flight crew/command module aboard Ticonderoga	14:30	0:00:40
Hatch open	14:35	0:00:45
Flight crew in Skylab mobile laboratory	14:40	0:00:50
Time critical experiment removal completed	18:19	0:04:29
Reaction control system depressurization started	20:15	0:06:25
Reaction control system depressurization completed	22:15	0:08:25
Experiment removal completed	22:15	0;09:50
	June 23, 1973 (recovery plus 1 day)	
Final hatch closure	18:15	1:04:25
	June 24, 1973 (recovery plus 2 days)	
Flight crew departed prime recovery ship for San Clemente (via El Toro)	15:00	2:01:10
Flight crew arrived San Clemente	17:00	2:03:10
Flight crew departed San Clemente for prime recovery ship (via El Toro)	17:30	2:03:40
Command module off loaded from Ticonderoga	18:00	2:04:10
Command module in hangar at North Island	18:25	2:04:35
Flight crew arrived at prime recovery ship	18:30	2:04:40
Flight crew departed prime recovery ship by limousine	23:10	2:07:20

TABLE 13-II.- RECOVERY EVENT TIMELINE - Concluded

Event	Time, G.m.t.	Time relative to landing, day:hr:min
	June 25, 1973 (recovery plus 3 days)	
Flight crew departed North Island on C-141	0:00	2:10:10
Flight crew arrived Ellington AFB on C-141	2:47	2:12:57
Skylab mobile laboratory off loaded from prime recovery ship	3:30	2:13:40
Skylab mobile laboratory departed North Island on C-5	6:16	2:16:26
Skylab mobile laboratory arrived Ellington AFB on C-5	9:24	2:19:34
Skylab mobile laboratory in place at Building 36	16:00	3:02:10
	June 28, 1973 (recovery plus 6 days)	
Command module deactivation completed	21:00	6:07:10
	June 29, 1973 (recovery plus 7 days)	
Command module departed San diego, California	4:00	6:14:10
Command module arrived Downey, California	7:00	6:17:00

14.0 ASSESSMENT OF MISSION OBJECTIVES

The primary mission objectives assigned to the first visit were:

a. Establish the Saturn Workshop in earth orbit.

1. Operate the orbital assembly (Saturn Workshop including command and service module) as a habitable space structure for up to 28 days.

2. Obtain data for evaluating the performance of the Saturn Workshop.

3. Obtain data for evaluating crew mobility and work capability in both intravehicular and extravehicular activity.

b. Obtain medical data on the crew for use in extending the duration of manned space flights.

1. Obtain medical data for determining the effect on the crew as a result of a space flight of up to 28 days.

2. Obtain medical data for determining if a subsequent visit of up to 56 days duration is feasible and advisable.

c. Perform inflight experiments

1. Obtain Apollo Telescope Mount solar astronomy data for continuing and extending solar studies beyond the limits of earth-based observations.

2. Obtain earth resources data for continuing and extending multi-sensor observation of the earth from low-earth orbit.

3. Perform the assigned scientific, engineering, and technology experiments.

Tables 14-I through 14-IV list the experiments and subsystem/operational detailed test objectives assigned to the first visit for which the Johnson Space Center is responsible, and defines the degree of completion of each objective. Since the data analysis is not completed, the tables indicate only the number of planned activities that were completed.

Television documentation of the first visit was also required with a total of 39 telecasts planned. Twenty-seven of the planned telecasts were completed and five telecasts, which were not planned, were also performed. Table 14-V is a listing of the telecasts which were completed.

TABLE 14-I.- MEDICAL EXPERIMENTS

Experiment	Performance		Remarks
	Planned[a]	Completed	
M071 - Mineral Balance	29	28	Each crewman each day
M073 - Bioassay of Body Fluids	29	28	
M074 - Specimen Mass Measurement	6	4	Electronics failed in one small mass measuring device after initial calibration
M078 - Bone Mineral Measurement[b]			
M092 - Lower Body Negative Pressure			
Commander	8	7	
Science Pilot	8	7	
Pilot	8	8	
M093 - Vectorcardiogram			
Commander	8	7	
Science Pilot	8	7	
Pilot	8	8	
M110 Series - Blood Study	4	4	
(M111[b], M112, M113, M114, M115)			
M131 - Human Vestibular Function			
Spatial Location - Commander	3	1	
Science Pilot	3	3	
Pilot	3	3	
OGI/MS - Science Pilot	5	4	
Pilot	5	3	
M133 - Sleep Monitoring	15	12	
M151 - Time and Motion Study			
M092/93 or M092/171	8	8	Photographs of the listed activities were required the number of times indicated
T027/S073	7	7	
S190B	3	2	
Suit Donning/Doffing	2	2	
Meal Preparation	4	4	
M171 - Metabolic Activity			
Commander	5	6	
Science Pilot	5	6	
Pilot	5	7	
M172 - Body Mass Measurement	3	3	

[a]Per launch flight plan.

[b]No inflight requirments.

TABLE 14-II.- EARTH RESOURCES EXPERIMENT PACKAGE
DATA COLLECTION FOR FIRST VISIT

Discipline	Task/sites		Task/ sites completed	Other task/sites partially completed
	Total	First visit		
Agriculture/range forestry	33	31	14	
Geology	55	55	30	3
Continental water resources	29	29	12	
Ocean investigations	38	30	6	4
Atmospheric investigations	58	47	19	4
Coastal zones, shoals, and bays	21	21	5	
Remote sensing techniques development	83	69	45[a]	21
Regional planning and development	89	86	38	3
Cartography	35	35	10	3
User agency tasks	92	92	12	15
Total	533	495	191	53

[a]Includes six task/sites associated with the lunar calibration.

TABLE 14-III.- COROLLARY EXPERIMENTS

Experiment	Performance		Remarks
	Planned	Completed	
C008 - Radiation in Spacecraft	31	28	
M509 - Astronaut Maneuvering equipment	0	0	Candidate for performance. Hardware check-out completed
M516 - Crew Activities	6	4	
S015 - Zero g Single Human Cell	1	0	Deleted from command and service module because of weight
S019 - Ultraviolet Stellar Astronomy	8	3+	Three passes plus four photographs from experiment ED23 pass
S020 - Ultraviolet X-ray Solar Photography	1	0	Solar airlock not available
S149 - Particle Collection	1	1	
T025 - Coronograph Contamination Measurement	2	0	Solar airlock not available

TABLE 14-IV.- SYSTEMS/OPERATIONAL DETAILED TEST OBJECTIVES

Experiment	Performance		Remarks
	planned	Actual	
Radiation measurement	37	28	
Portable carbon dioxide/ dew point monitor	2	1	Instrument failed
Water sample	1	1	
Microbiological sample	4	4	
Carbon monoxide monitor	4	2	Does not include carbon monoxide monitoring during Orbital Workshop activation
Iodine monitor	4	4	
Spacecraft/launch vehicle adapter deployment observation	1	1	

TABLE 14-V.- FIRST VISIT TELEVISION SUMMARY

Visit day	Procedure designation	Activity observed
2	TV-41	Rendezvous
3	—	Parasol deployment
3	—	Orbital Workshop checkout
4	TV-27	Press conference
5	TV-1	Specimen mass measurement device/water gun activities
5	TV-2	Preparing meal
6	TV-3	Eating
7	TV-13	Apollo Telescope Mount operations
8	—	Crew day off activities
9	TV-11	Earth Resources Experiment Package operations
10	TV-37	Out-the-window view
12	TV-19	Experiment M131 (Human Vestibular Function, Oculogyral I)
12	TV-12	Additional Earth Resources Experiment Package operations
13	TV-4	Experiment M110 - (Blood Sampling)
13	—	Extravehicular activity simulation
14	—	Extravehicular activity operations
16	TV-6	Experiment M092 (Lower Body Negative Pressure) operations
17	TV-9	Experiment M171 (Metabolic Activity) operations
18	TV-7	Additional experiment M092 (Lower Body Negative Pressure) operations
19	TV-24	Experiment M551 (Metals Melting) operations
19	TV-29	Earth observations with viewfinder tracking system
20	TV-20	Experiment M131 (Human Vestibular Function) operations
20	TV-29	Earth observations with viewfinder tracking system
22	TV-18	Experiment ED31 (Bacteria and Spores) operations
22	TV-25	First crew tour of Workshop
23	TV-26	Second crew tour of Workshop
24	TV-5	Experiment M172 (Body Mass Measurement Device) operations
24	TV-15	Sleep station, shower, trash, etc.
25	TV-28	Science Pilot highlights
26	TV-43	Extravehicular activity performing Apollo Telescope Mount film change
27	TV-27	Press conference
28	TV-42	Undocking and flyaround inspection

A summary assessment of mission objectives accomplished shows a very high degree of completion, especially considering the reduction in experiment time due to parasol deployment, solar array wing deployment, and Saturn Workshop system anomalies. All primary mission objectives were accomplished and a majority of the assigned experiment detailed objectives were completed.

15.0 FLIGHT PLANNING

15.1 SUMMARY

In Skylab flight planning, new techniques were applied to provide a great deal more flexibility in accommodating changes to the flight plan. Several factors such as the long mission duration and the fact that this was the first visit made it difficult to preplan with any degree of precision. Many of the experiments were also subject to unpredictable factors such as weather (Earth Resources Experiment Package), solar activity (Apollo Telescope Mount experiments), and crew condition (medical experiments). Finally, flight planning had to be flexible enough to react to changes in emphasis in objectives and changes in experiment capabilities resulting from hardware problems.

Such flexibility essentially meant the flight plan was revised on a day to day basis, and the updated flight plan had to be forwarded to the crew with a minimum of interference with other duties. Updating the flight plans as well as transmitting other messages was accomplished on Skylab using a teleprinter device onboard the Orbital Workshop. An example of a typical teleprinter message is shown in figure 15-1.

15.2 IMPLEMENTATION

Twenty four hour Mission Control Center support operations were divided into the summary, execute, and detail shifts. The relationship of these shifts to the crew day is shown in figure 15-2.

The flight planning sequence began with the summary shift on the morning of day n, where a general plan for day n+1 was worked out to the level of detail shown in figure 15-3. A summary plan, shown in figure 15-4, was transmitted near the end of the workday to enable the crew to discuss the next day's flight plan during their pre-sleep period. During the detail shift on the evening of day n, the n+1 plan, including any late necessary modifications which were discovered during the crew workday, would be developed to the level necessary to generate the detailed flight plan (e.g., switch on times, pointing angles, maneuver times, etc.). The detailed flight plan for day n+1 was then uplinked to the Orbital Workshop via the teleprinter during the crew sleep period and was available to the crew for implementation on the prescribed day. An example of a portion of the detailed flight plan is shown in figure 15-5.

```
57171              TELEPRINTER LOAD TABLE 2             1482  1482
                                                    GMT 162:03:11:24
   LOAD NO. 4101        MSG NO  MSG TITLE   LGTH ORIG/CODE
   TOTAL LINES 30       1809C1 SAP           30   DH /FC8
   SITES HSK/
   LOAD AT SITE YES

1809C1 058 SAP               18/162 |01 |BEEN LOWERED AS A RESULT OF   .
------------------------------------|02 |PMEC CALIB. ON CON XRAY THRES-
TGT! T/R !FLARE PROBABILITY        .|03 |HOLD IS LOWER THAN THE NORTH .
------------------------------------|04 |HORN.                         .
------------------------------------|05 |-------------------------------
 27! 7/.6!FP5/0/0                  .|06 |
 31!31/.4!FP9/2/0                  .|07 |
 32!23/.4!FP7/0/0                  .|08 |
 35!25/.7!FP1/0/0                  .|09 |
 37!28/.9!FP9/4/0                  .|10 |
P71!12/1.!                         .|11 |
F74!35/.8!                         .|12 |
F78! 4/.9!                         .|13 |
F79!28/.9!                         .|14 |
------------------------------------|15 |
DELTA IN AR31 WEAKENING. NORTH      |16 |
EAST LIMB AND NEAR LIMB ACTIVE      |17 |
------------------------------------|18 |
BEGINNING STUDY OF AR37 AS IT.      |19 |
EMERGES FROM THE EAST LIMB.        .|20 |
TODAY PROVIDES THE FIRST OP-       .|21 |
PORTUNITY FOR SUNSPOT OBSERVA-      |22 |
TION. THE STREAMER AT 29/1 CO-      |23 |
NTINUES TO SHOW CHANGES AS A       .|24 |
RESULT OF SOLAR ACTIVITY. NOTE      |25 |
THAT FLARE THRESHOLDS HAVE         .
```

16

OPR 0   4   NO 0   3   2   1   S2C   5

Figure 15-1.- Typical teleprinter message.

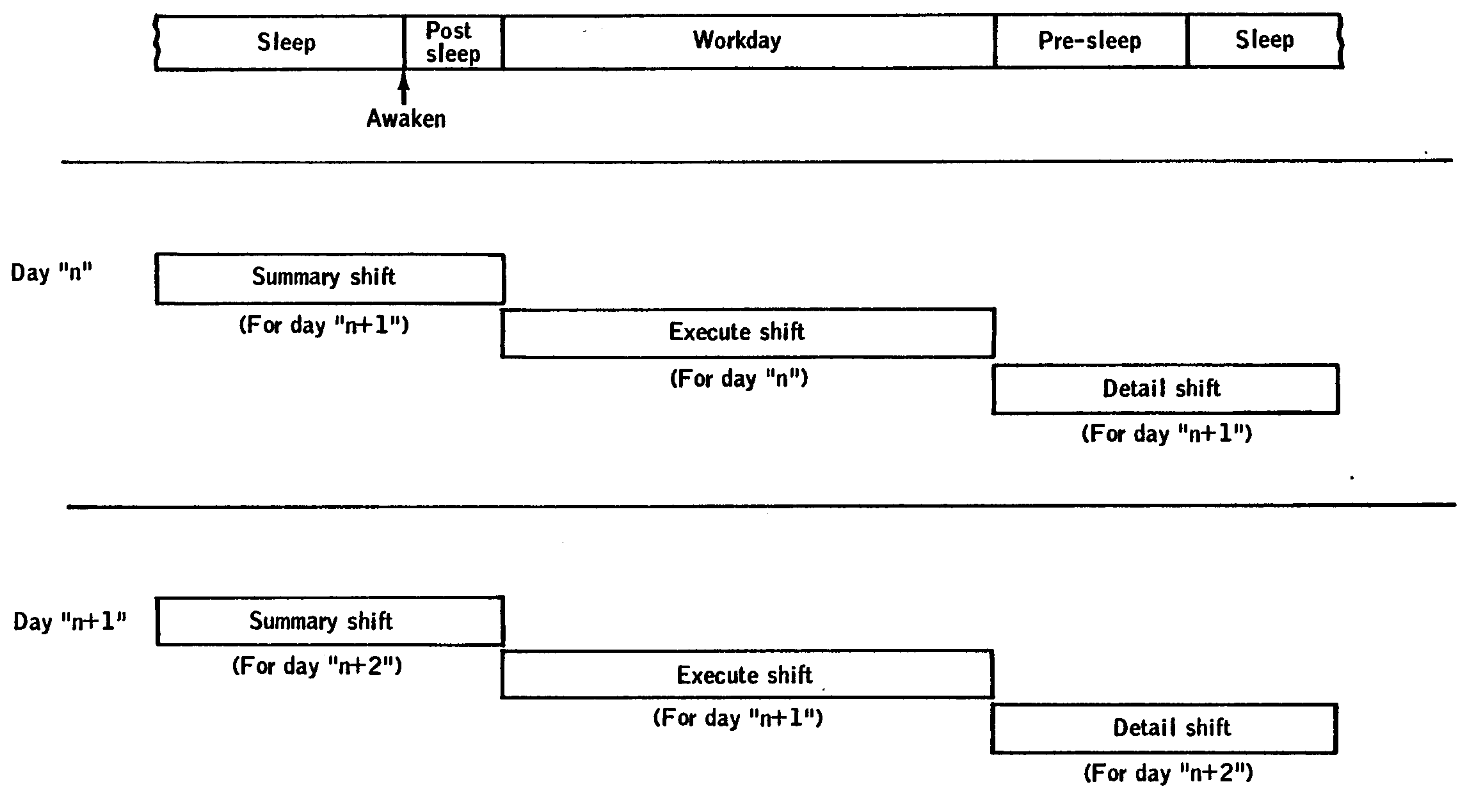


Figure 15-2. - Crew workday and ground support shift schedule.

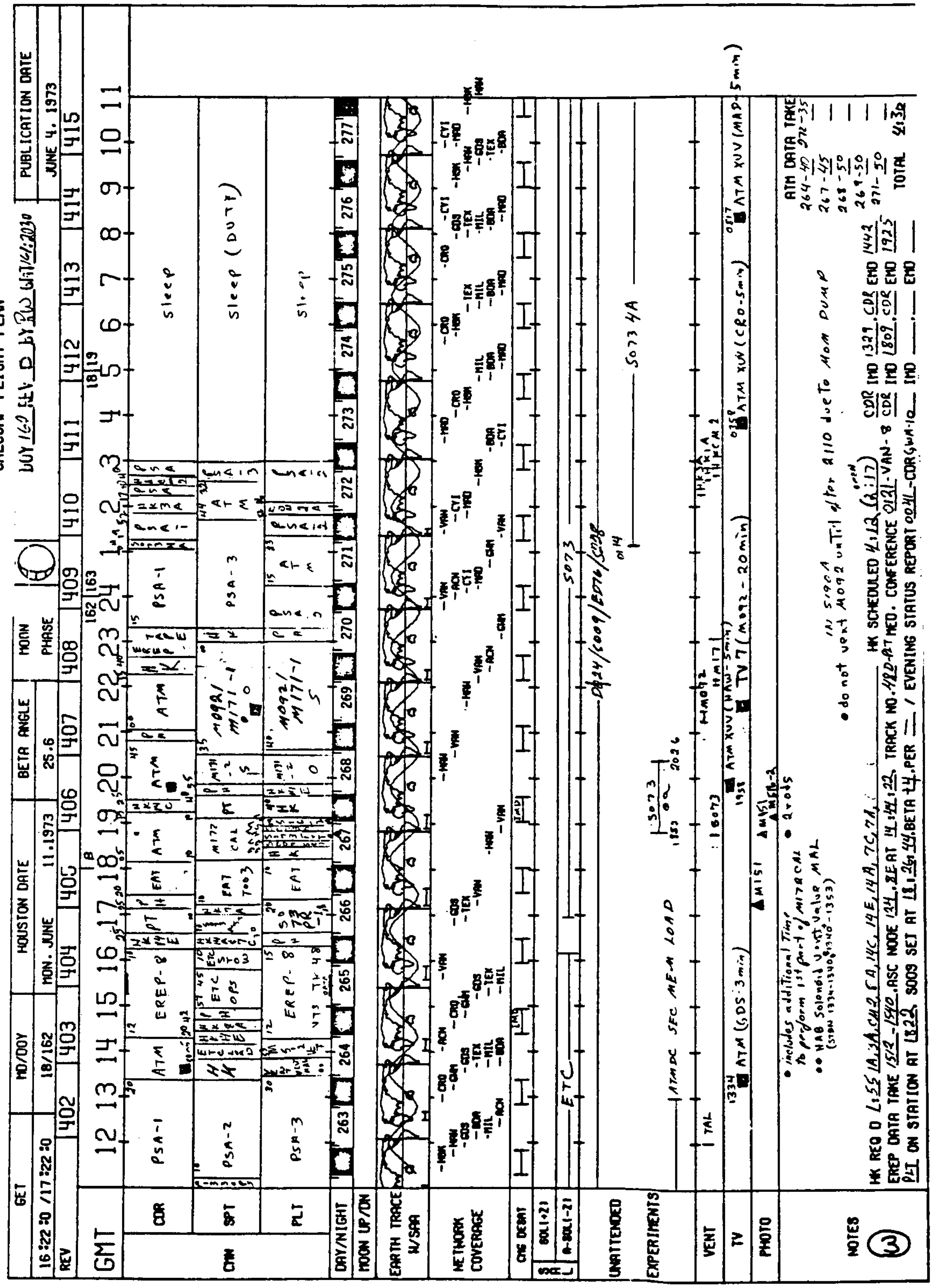


Figure 15-3.- Typical summary flight plan.

```
S7170              TELEPRINTER LOAD TABLE 1        1481   1481
                                               GMT 162:07:51:43
     LOAD NO. 4001        MSG NO  MSG TITLE   LGTH ORIG/CODE
     TOTAL LINES 36       1811B   EREP 08 PREP  36   HS /FC91
     SITES GDS/TEX
     LOAD AT SITE YES

1811B  036 EREP 08 PREP 18/162|01|S191 !CALIB-9/REF-5             .
------------------------------|02|S190 !SS- SLOW/FR-42/IVL-18     .
BEGIN PREP:1412 REV 403/404  .|03|S193 !XTC     /ANG-P+30/POL-1  .
LONG 124.8E       GMT 1444:22.|04|S193A!MODE-1    /RANGE-76       .
------------------------------|05|S194 !AUTO B                    .
S191    DAC 05    MAG BH02(J4).|06|--------------------------------
------------------------------|07|REMARKS: START ZLV MNVR          .
S190 PREP      DRAWER L (SET P)|08|  14:54:00. DO SENSITOMETRY    .
CAM APERT FLTR!CAM APERT FLTR!|09|  ADVANCE.                      .
---!-----!----!---!-----!----!|10|--------------------------------
 1 ! 6.7 ! CC ! 4 ! 4.8 ! FF !|11|1811B  036 EREP 08 PREP     EOM
 2 ! 6.7 ! DD ! 5 ! 5.6 ! BB !|12|
 3 !11.0 ! EE ! 6 ! 5.6 ! AA !|13|
------------------------------|14|
GMT!          WARMUPS        .|15|
---!--------------------------|16|
1442!S192 HI/LO/HI           .|17|
    !S191 COOLER             .|18|
    !S190 POWER ON           .|19|
    !S193R,S                 .|20|
    !S194                    .|21|
------------------------------|22|
EXP !  READY-VERIFICATION    .|23|
------------------------------|24|
S192 !CALIB-HI/LO/HI         .|25|
```

Figure 15-4.- Typical section of a detailed flight plan transmitted to the crew.

```
                        TELEPRINTER LOAD TABLE 4                 GMT 161:22:25:53
     LOAD NO. #301        MSG NO   MSG TITLE    LGTH  ORIG/CODE
     TOTAL LINES 50       180181 FLIGHT PLAN     50    JLH/CG53
     SITES VAN/ACN
     LOAD AT SITE YES

180151 089 FLIGHT PLAN   18/162 |01|   !          !  M172    !S009 SET!
--------------------------------|02|   !   ATM    !  CAL     !S073 EXT!
GMT CDR-11 ! SPT-23 ! PLT-32   !|03|19+          +         + (M151) +
13+        +        +          +|04|   !--HK14C-!---------!S073 OA  !
  !--------!   HK   !           |05|   !---------! PT&PH   ! M516-2  !
  !  ATM   !        !VENT-VLV  !|06|   !          !         ! HK14E   !
  !        !ETC-LOAD!MAL(PAD)  !|07|20+   ATM    +-M131-2-+-M131-2--+
14+        +-HK14E--+M512 VER  +|08|   !          !SUBJECT  !OBSERVER!
  !--------!--------!----------!|09|   !          !---------!---------!
  !        ! HK8A   !          !|10|   !---------!         !         !
  ! EREP-8 !--------! EREP-8   !|11|21+---------+ M092/   + M092/   +
15+ DATA   +--------+  VTS     +|12|   !          ! M171-1  ! M171-1  !
  !  TAKE  !ETC OPS !OPERATOR  !|13|   !   ATM    !OBSERVER !SUBJECT  !
  ! 1512-  !        ! TRACK    !|14|   !          ! (TV-7)  !         !
  !  1540  !--------!  48D     !|15|22+          +         +         +
16+        +ETC STOW+          +|16|   !---------!         !         !
  !--------!HK14A87C!----------!|17|   !   HK     !         !         !
  !-HK14E--!--------!----------!|18|   !---------!         !         !
  !   PT   !S073ASST!S073PR-1  !|19|23+EREPTAPE+---HK----+---------+
17+--------+--HK7A--+ (M151)   +|20|   !---------!---------!---------!
  !--------!--------!----------!|21|   !          !         !         !
  !        !        !          !|22|   !          !         !  PSA    !
  !  EAT   !  EAT   !   EAT    !|23|24+   PSA    +  PSA    +         +
  !        !  T003  +          +|24|   !          !         !---------!
18+--------+        !---HK-----!|25|   !          !         !         !
```

Figure 15-5.- Summary flight plan of the type transmitted to the crew.

In addition to the scheduled activities in the day's flight plan, the crew was also provided with optional activities on a "shopping list" which could be performed if the opportunity was available either during the normal workday or during the pre-sleep and post-sleep periods.

Exclusive of the operational inputs to the flight plan (maneuvers, housekeeping, etc.), the major inputs to the summary plan were made by representatives from the medical, Earth Resources Experiment Package, Apollo Telescope Mount, and corollary experiments groups. Conflicts in the available time between these disciplines were ultimately resolved by the Flight Director based upon recommendations by the Program Scientist, the Flight Operations Management Room Manager, and others. In addition, the experiments groups could appeal decisions in the daily Flight Management Team meetings, which were chaired by the Program Director and were held at the beginning of the execute shift.

15.3 ASSESSMENT

Visit accomplishments in terms of experiments and test objectives are discussed in section 14.0. In general, a high level of accomplishment was achieved in spite of initial power limitations and the loss in experiment time as a result of an additional extravehicular activity. The lost time was compensated for when the crew recommended deleting the weekly day off and by their zeal in accomplishing the items of the "shopping list" during their free time. Table 15-I shows the breakdown of accomplishments in terms of crew time and compares the actuals with the preflight plan.

The techniques for flight planning worked well for the first visit. This is especially important in view of the diverse requirements of the widely different scientific disciplines on the Skylab program. Besides the simple competition for crew time among the experiments, there was competition for utilization of the scientific airlock (only one experiment could be accommodated at a time), as well as competing requirements on the Workshop attitude. Such conflicts are inherent in a program which encompasses such a wide range of experiments, and such conflicts were anticipated prior to flight. The role of Program Scientist had been created especially to resolve such interdisciplinary conflicts and to promote better understanding between the scientific investigators on flight planning problems. Observations during the progress of the visit and discussions with the various experiment groups subsequent to the visit have indicated that this worked effectively. The experiment groups suggested the following areas where improvements in the flight planning area could be made on subsequent visits. These suggestions are listed below and these will be factored into the planning.

TABLE 15-I.- BREAKDOWN OF ACTUAL CREW TIME ALLOCATION VERSUS PREFLIGHT PLAN

Category	Manhours utilization, hr:min (percent of total)	
	Actual	Preflight allocation
Medical Experiments	145:13 (7.4)	157:51 (8.0)
Apollo Telescope Mount	117:09 (6.0)	152:51 (7.7)
Earth Resources Experiment Package	71:24 (3.6)	85:55 (4.3)
Corollary experiments	54:24 (2.8)	62:20 (3.2)
Subsystem detailed test objective	7:03 (0.4)	7:07 (0.4)
Student experiments	3:41 (0.2)	4:41 (0.2)
Operational[a]	1562:07 (79.6)	1509:39 (76.2)

[a]Includes sleeping, eating, housekeeping, etc.

a. Increased flexibility for real time changes to the flight plan.

b. A better understanding of the long range planning forecast beyond the day n+1 flight plan.

c. Improved capability for communicating experiment related questions to the crew.

d. Better communications between the various experiment disciplines regarding their mutual interests and problems involved with scheduling conflicts.

16.0 LAUNCH PHASE SUMMARY

16.1 WEATHER CONDITIONS

At launch time, a west southwest wind prevailed over the launch area and northern Florida in the lower troposphere, from the surface to an altitude of 5.5 kilometers. Above this level, in the troposphere, wind directions were from west and west northwest. The maximum wind observed was 34 meters per second from an azimuth of 290° at an altitude of 14 kilometers.

A surface low pressure trough lay across northern Florida, southern Georgia, and Alabama, the axis of which was oriented from east northeast to west southwest. An extensive area of scattered showers, and broken layers of middle and high cloudiness with widely scattered embedded thunderstorms extended southward from the trough axis to central Florida. Broken layers of clouds over the launch area were observed at 150 meters, 2100 meters, and 5500 meters. Showers were observed 16 to 24 kilometers south of the launch pad.

16.2 LAUNCH VEHICLE PERFORMANCE

The Saturn space vehicle supported the first visit by placing the spacecraft into an earth orbit for subsequent rendezvous with the Saturn Workshop. The performance of the space vehicle will be reported in detail in the Marshall Space Flight Center's Saturn Workshop Report which will be incorporated as Volume III of the Skylab Mission Evaluation Report to be published by NASA Headquarters.

The performance of ground systems supporting the countdown and launch was satisfactory except for one anomaly. This anomaly, an erroneous cutoff signal, occurred after the launch commitment was made and could have transferred vehicle power from the internal to the external source. This transfer would have resulted in a launch without vehicle electrical power. The erroneous cutoff signal, however, was not sustained long enough to energize the cutoff relay. Damage to the pad, launch umbilical tower, and support equipment was minimal.

The vehicle was launched on an azimuth due east. A roll maneuver was initiated at approximately 10 seconds that placed the vehicle on a flight azimuth of 47.580 degrees. The downrange pitch program was also initiated at this time. The flight trajectory was very close to the predicted operational trajectory. The S-IB stage outboard engine cutoff was

1.36 seconds later than nominal. The total space fixed velocity at this time was 7.07 meters per second greater than planned. After separation, the S-IB stage continued on a ballistic trajectory to earth impact. The S-IVB stage firing terminated with guidance cutoff signal and parking orbit insertion; both approximately 3.7 seconds later than planned. A velocity of 1.82 meters per second greater than nominal at insertion resulted in an apogee 6.32 kilometers higher than nominal. The parking orbit portion of the trajectory until spacecraft/launch vehicle separation was close to nominal.

All aspects of the S-IVB/instrument unit deorbit were accomplished successfully. The deorbit trajectory altitude was slightly higher than the real time predicted value, resulting in an impact slightly downrange of nominal. These dispersions were small enough that impact actually did occur within the real-time predicted footprint.

The S-IB stage propulsion system performed satisfactorily throughout the flight. The S-IVB stage propulsion system performed satisfactorily throughout the operational phase of the firing and had normal start and cutoff transients. Subsequent to the firing, the stage propellant tanks were vented satisfactorily, and the impulse derived from the liquid oxygen and fuel dumps was sufficient to satisfactorily deorbit the S-IVB/Instrument Unit. A disturbing force on the S-IVB/Instrument Unit, coincident with liquid oxygen tank venting, caused unplanned firings of auxiliary propulsion system module engines and subsequent propellant depletion in auxiliary propulsion system module 2. Analysis indicated nearly complete blockage of the liquid oxygen nonpropulsive vent nozzle 1. The blockage has been attributed to solid oxygen formation at the nozzle inlet during cyclic liquid oxygen relief venting when liquid remaining in the duct was subjected to a freezing environment. No impact due to this anomaly is expected on the following missions.

The structural loads during the flight were well below design values. Thrust cutoff transients were similar to those of previous flights.

The stabilized platform and the guidance computer successfully supported the accomplishment of the mission objectives. Targeted conditions at orbit insertion were attained with insignificant error. The one anomaly which occurred in the guidance and navigation system was a large change in the gyro summation current and a small change in the accelerometer summation current. Operation of the system was not affected by these current changes.

The control and separation systems functioned correctly throughout the powered and coasting flight. The electrical systems and emergency detection system performed satisfactorily during the flight. Battery performance was satisfactory.

17.0 ANOMALY SUMMARY

17.1 COMMAND AND SERVICE MODULE ANOMALIES

17.1.1 Suit-to-Cabin Differential Pressure was Negative

The command module suit circuit pressure dropped below the cabin pressures and cycled between approximately plus 0.05 newtons per square centimeter of water and minus 0.05 newtons per square centimeter of water differential pressure during the final 32 minutes of the countdown. The suit circuit pressure remained below cabin pressure for approximately 15 minutes and rose above cabin pressure only after the direct oxygen flow was increased from 0.247 to 0.333 kilograms per hour and the Commander and Science Pilot moved their suit hoses. The suit circuit pressure again decreased below cabin pressure for a short period prior to launch.

While the low pressure excursions were occurring, the crew was operating on the suit loop. Oxygen was being supplied at 0.247 kilograms per hour through the direct oxygen valve and the system was relieving into the cabin through the suit circuit demand regulator relief valve. The relief valve should have maintained the lowest pressure in the suit circuit approximately 0.055 newtons per square centimeter of water above the cabin pressure. A suit circuit schematic is shown in figure 17.1-1.

The pressure decrease could only have been caused by leakage from the suit loop into the cabin. Also, as the inlet side of the compressor was below the cabin pressure, the leak must have been at a point where the suit loop pressure was above cabin pressure, that is, between the compressor outlet and the suit outlet.

Several possible failures could have caused leakage in this part of the suit circuit. First, one or more of the suits could have had a low-pressure leak which resulted in the suit and cabin pressure being equal at the point of the leak. This would create a negative pressure at the compressor inlet where the pressure transducer is located. However, postflight tests showed the low pressure suit leakage to be too low to have caused the problem. Second, the suit circuit could have had a low pressure leak at a seal or joint. However, no such leak was found in postflight tests. Third, the interface between the suits and the suit circuit could have had a low pressure leak. This interface was tested and leakage was acceptable. The connectors from the suit hose to the command module suit circuit were inspected after the leakage test and were normal.

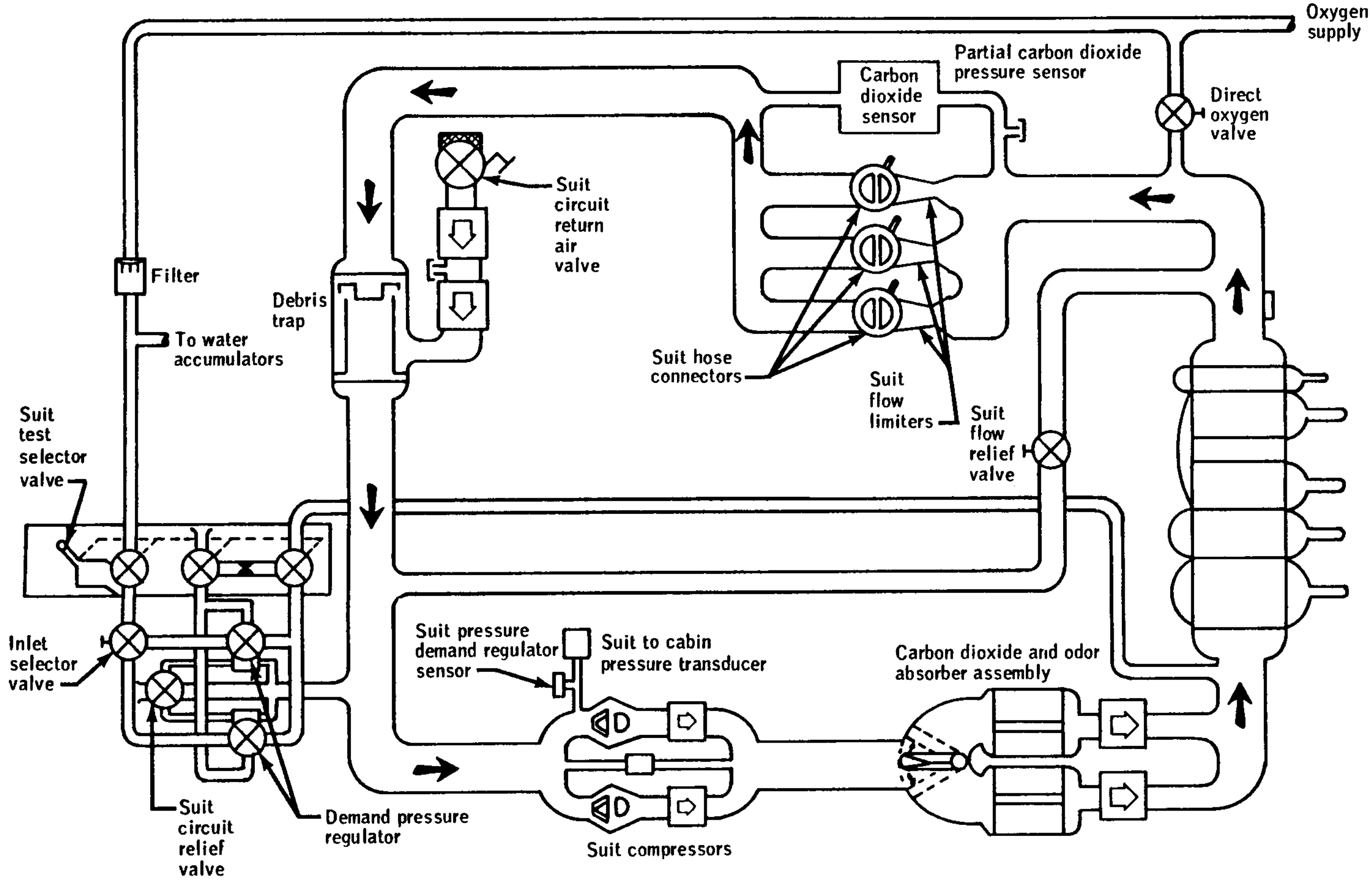


Figure 17.1-1.- Suit circuit.

The only component that displayed excessive low pressure leakage during postflight testing was the suit circuit air return check valve. However, this valve is located near the pressure transducer in the suit circuit and could not have caused the negative pressure.

In addition to the possible failure modes discussed, tested, and evaluated, the circuit demand regulator and relief valve were tested and found normal.

All potential causes of this problem have been tested and are normal. Therefore, the most probable cause of this problem was an intermittent leakage at low differential pressures not apparent during the postflight testing. Should the problem recur on another command module to the extent observed on this first visit vehicle, adequate oxygen is available through the direct oxygen valve to accommodate leakages of up to 4.25 kilograms per hour for extended operations and up to 19.0 kilograms per hour for 10 minutes.

This anomaly is closed.

17.1.2 Service Module Quad A Pressure/Temperature Sensor Failed

The service module reaction control system quad A and the propellant storage module propellant quantity measurements failed off scale high. Both measurements indicated off scale high from helium loading during prelaunch operations until the end of the first visit; consequently, the failure could have occurred before launch.

The quantity transducer (fig. 17.1-2) consists of four silicon (semiconductor) strain gages connected as a resistance bridge. The bridge is mounted on a diaphragm that is exposed to the helium tank pressure. The gage elements are temperature sensitive; consequently, the bridge output is proportional to the helium pressure divided by the helium temperature. The bridge output is amplified by a differential amplifier and supplied to the instrumentation system as a 0 to 5 volt dc signal.

All four quantity measurements on Apollo 12 failed as a result of the vehicle being struck by lightning during the launch phase. The launch umbilical tower on the second visit vehicle was also struck by lightning during ground checkout and four of the five quantity measurements failed (the propellant storage module was not flown on Apollo vehicles). Since the umbilical tower was struck by lightning the night before launch, the failed quantity measurements probably resulted from this lightning strike.

Analysis of the transducers from the second visit vehicle after the lightning strike showed that in each case, one of the two differential output transistors (Q1 and Q2 in fig. 17.1-2) was shorted. (The Apollo 12 and first manned vehicle transducers were not recovered as they were located in the service module).

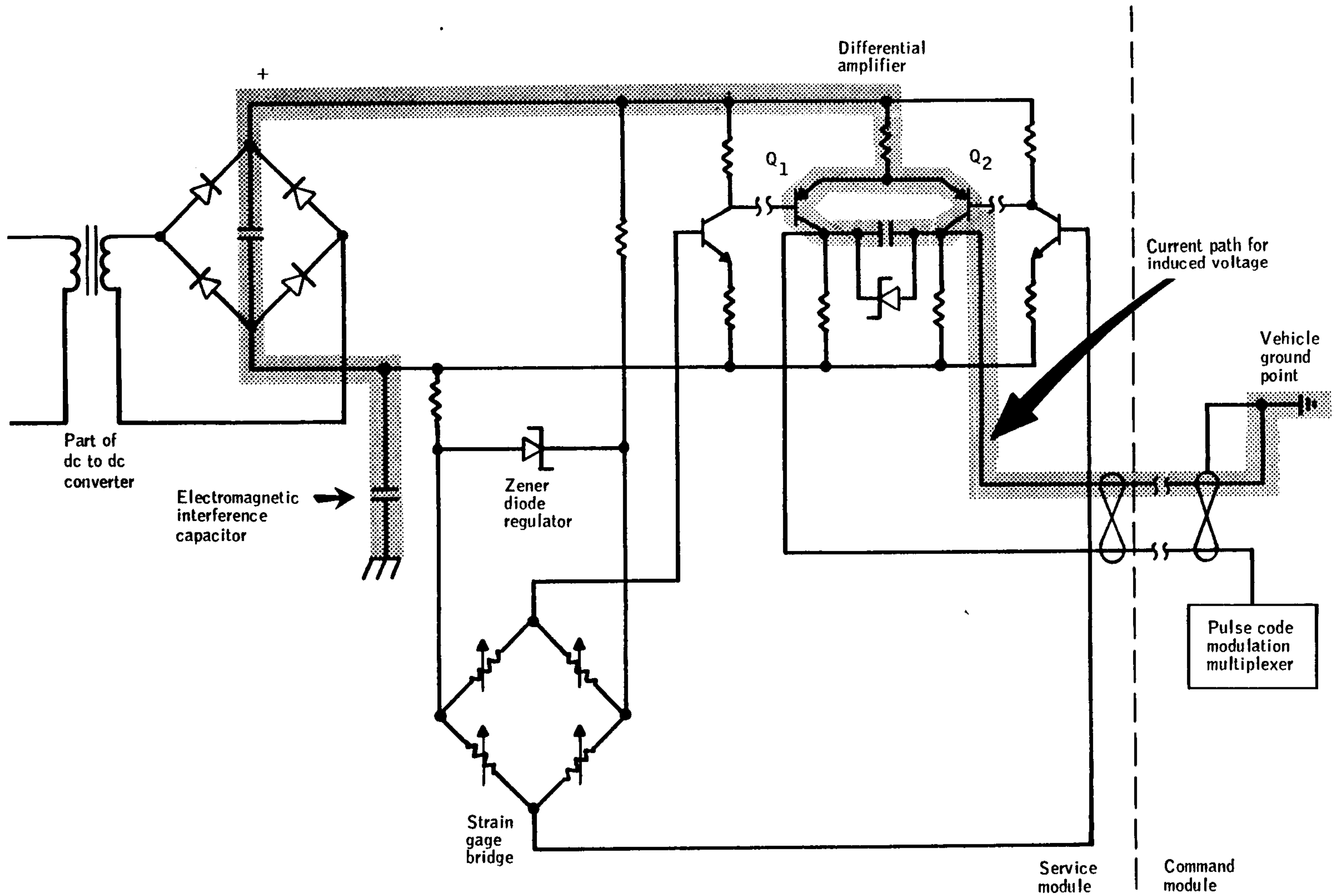


Figure 17.1-2.- Propellant quantity measurement circuitry.

The quantity transducer contains an electromagnetic interference capacitor that is connected between the negative output of the signal conditioner power supply and vehicle structure in the service module (fig. 17.1-2). Similar transducers located in the same area as the quantity measurement transducers do not use an electromagnetic interference capacitor and did not fail. The negative side of the differential amplifier and the shield of the cable that connects the signal conditioner to the pulse code modulation system are connected to ground and structure in the command module. Lightning induced voltages between these two ground points must, therefore, be imposed between the collectors and emitters of the two differential output transistors, with the weakest transistor of the two short circuiting (fig. 17.1-2).

Ground calculations are the prime mode used to determine propellant quantity. A computer program performs a pressure/volume/temperature balance calculation with the helium source pressure and temperature and propellant tank pressures and temperature. Gaging status data are relayed to the crew. Since the quantity measurements are used only as a backup to the ground calculations, no corrective action will be taken.

This anomaly is closed.

17.1.3 Failure to Achieve Docking Probe Capture Latch Engagement

Eight docking attempts were required to successfully achieve a hard docking following the standup extravehicular activity. Although capture latch engagement (soft dock) and undocking were successfully achieved prior to the standup extravehicular activity, the subsequent eight attempts never resulted in capture latch engagement and hard docking was performed using the emergency docking procedure. Upon removal of the probe, the crew noted that one of the three capture latch hooks had not returned to the lock position. Subsequent troubleshooting resulted in an additional hangup. Continued efforts, however, restored normal operation and, when used for undocking, the docking system worked properly.

The docking probe (fig. 17.1-3) is a tripod mounted device that serves as the active portion of the docking system. The probe incorporates provisions for the initial capture of the Multiple Docking Adapter drogue, energy attenuation, command module/Workshop retraction, relative vehicle alignment, and undocking. The structural items (fig. 17.1-4) consist of the central cylinder, a piston, a collar, three pitch arms, three shock struts, and the three support arms. The primary subassemblies of the probe consist of the capture latch assembly, the actuator assembly, the capture latch release handle, the nitrogen pressure system, the ratchet handle assembly, the extend latch/preload assembly, the shock struts, and the attenuators.

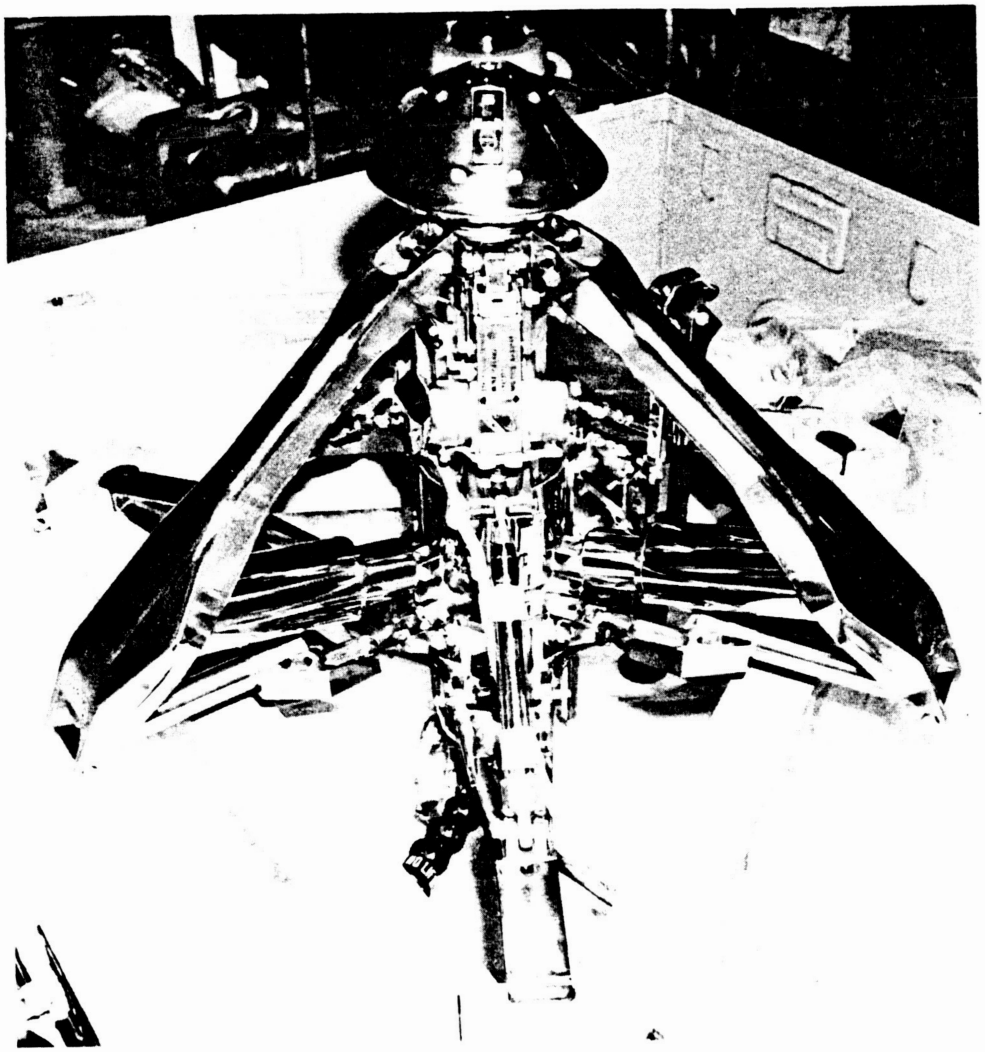


Figure 17.1-3.- Probe assembly.

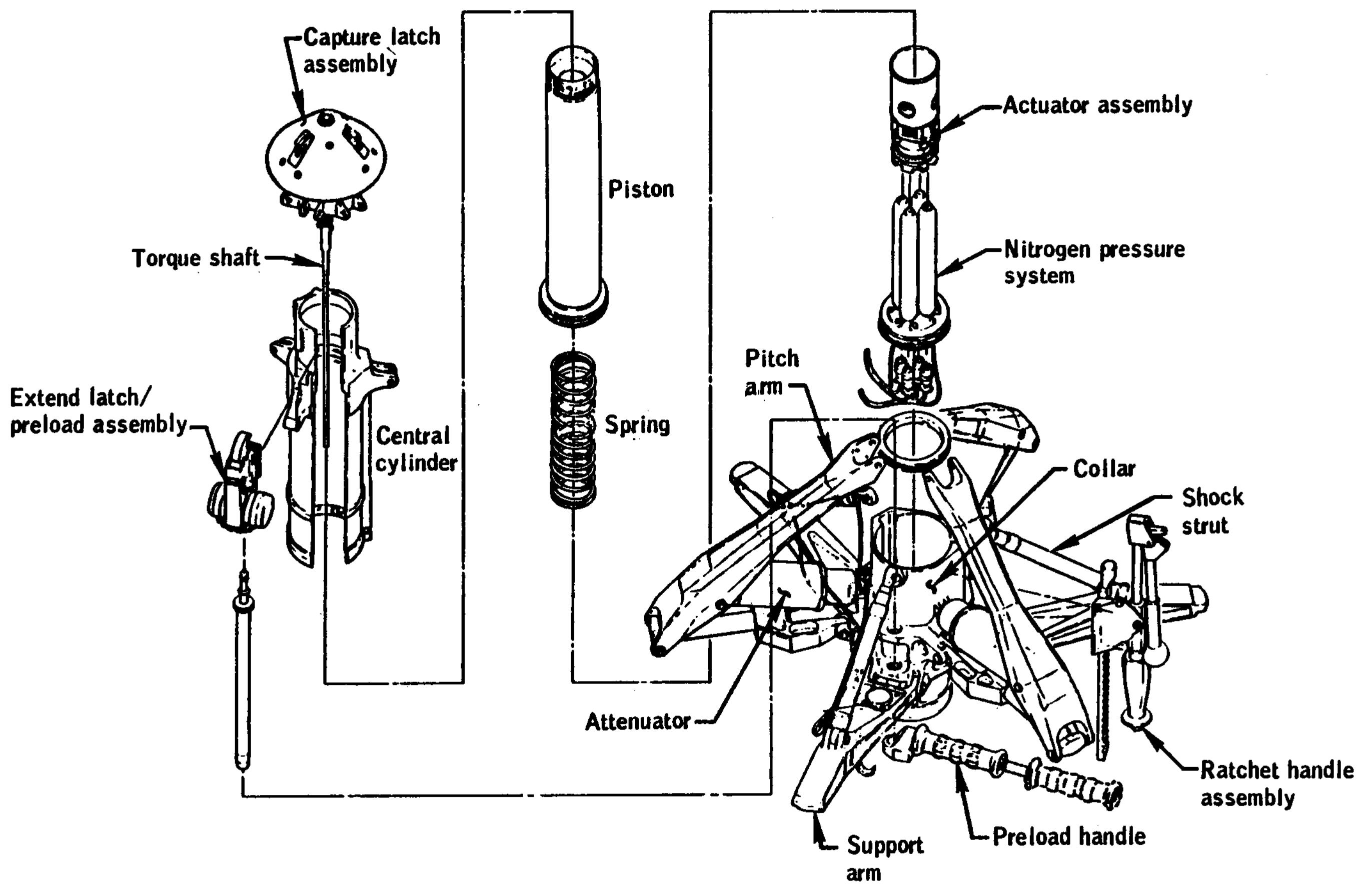


Figure 17.1-4.- Structural items of probe assembly.

The probe capture latch assembly (fig. 17.1-5) is contained within the probe head and provides the initial coupling between the command module and workshop. The assembly (fig. 17.1-6) consists of three latch hooks which are pin mounted in the probe head and spring loaded such that the hook protrudes beyond the surface of the probe head. Opposite each of the latch hook pivot points is a two piece toggle link that connects the latch hook to a fixed point on the probe head.

Locking and releasing of the latch hook is determined by the axial position of a single, symmetrical spider (fig. 17.1-7) which is spring loaded to the full forward (locked) position (fig. 17.1-8). In this position, a roller on the spider rests beneath each of the latch hook toggle links such that the latch hooks can be depressed. To unlock the latch hooks, the spider is moved aft where it is retained until a subsequent latch lock is required.

Spider retention and release is achieved by triggers located within each of the latch hooks. When the spider is moved aft of the spring-loaded triggers and released, pins located on the outer tip of the spider (fig. 17.1-8) rest against the back face of the trigger and thereby prevent forward travel of the spider. To release the spider, all three triggers must be depressed simultaneously since any one of the triggers will retain the spider in the aft position. In addition, each of the hooks must be fully extended or the toggle link will prevent the spider from moving forward. The spider can be moved from the forward to the aft position by manually depressing the plunger in the probe head or by rotating the torque shaft. The torque shaft has two rollers which ride in helical slots in a cam (fig. 17.1-8). The cam is attached to the spider with a tension link. When the torque shaft is rotated by either manually actuating the capture latch release handle or by powering the torque motors in the actuator assembly (fig. 17.1-9), the rollers turn in the cam slots and force the cam and the spider aft (fig. 17.1-8). When power is removed from the torque motors, the torsion spring on the torque shaft rotates the shaft back and allows the spider to move forward until cocked, i.e., the spider pins ride against the back of the triggers.

The drogue, a truncated cone structure that is installed in the Multiple Docking Adapter axial port tunnel, serves as a guide and receiver for the probe head.

The capture latch release handle (fig. 17.1-10) is located on the aft end of the probe and provides a means for manual release of the capture latches when the probe is in the retracted position. The probe must be retracted for the capture latch torque shaft to mate with the keyed female telescoping drive shaft. The release handle is secured on the pyrotechnic cover by spring clip detents and a manual locking lever. Normally, prior to folding the probe for removal from the command module tunnel, the release handle is unlocked and pulled from the spring clips.

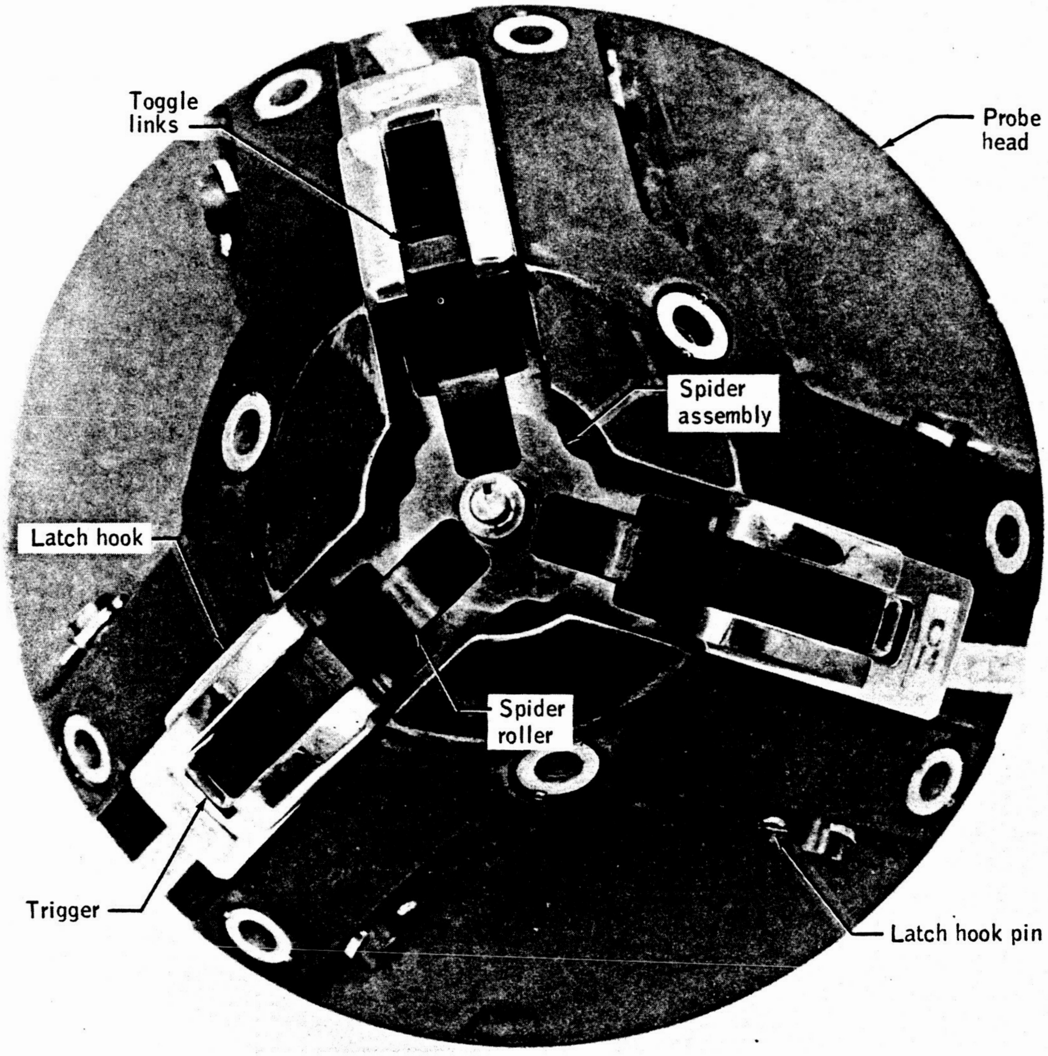


Figure 17.1-5.- Probe capture latch assembly.

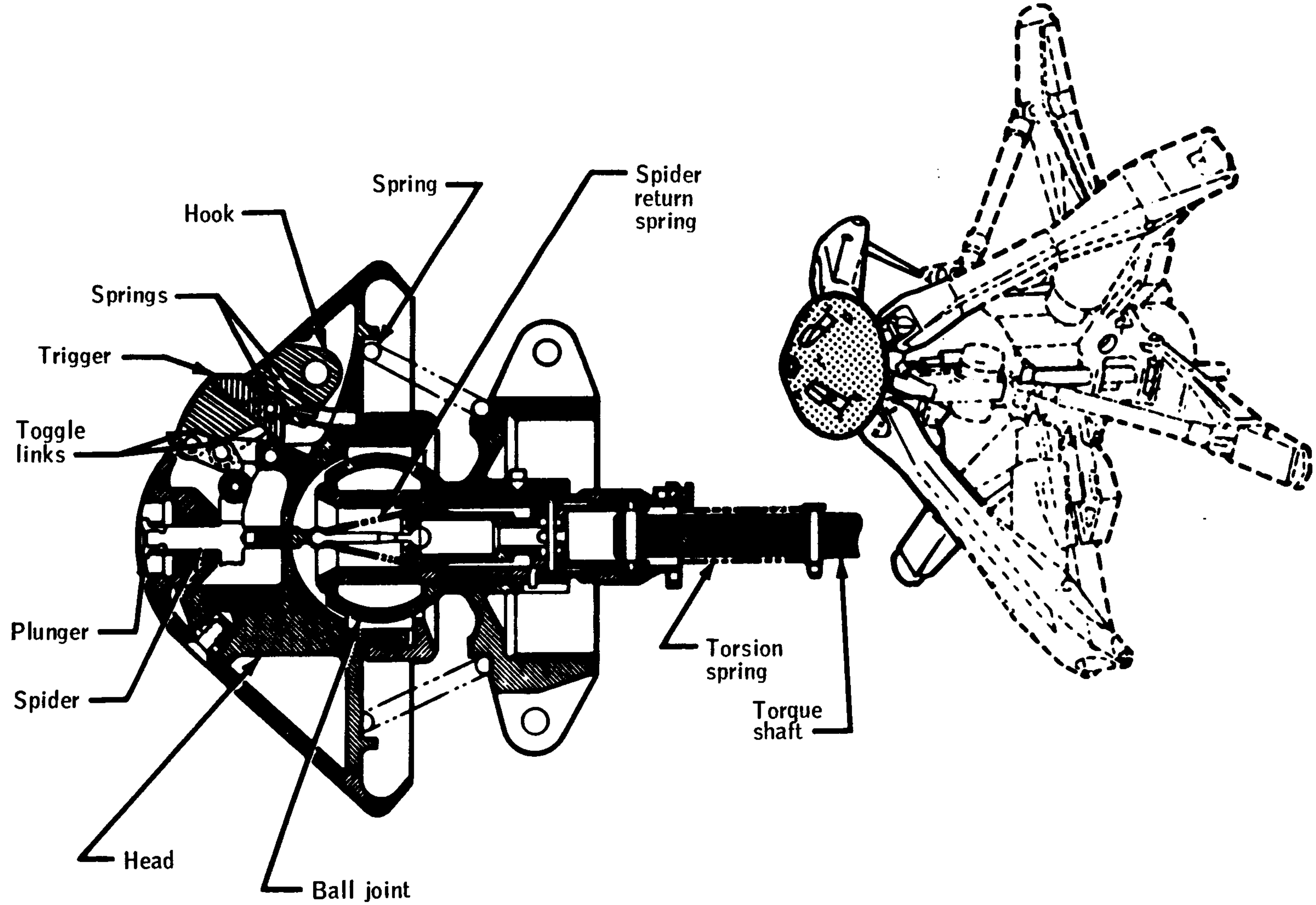


Figure 17.1-6.- Probe capture latch assembly shown in locked position.

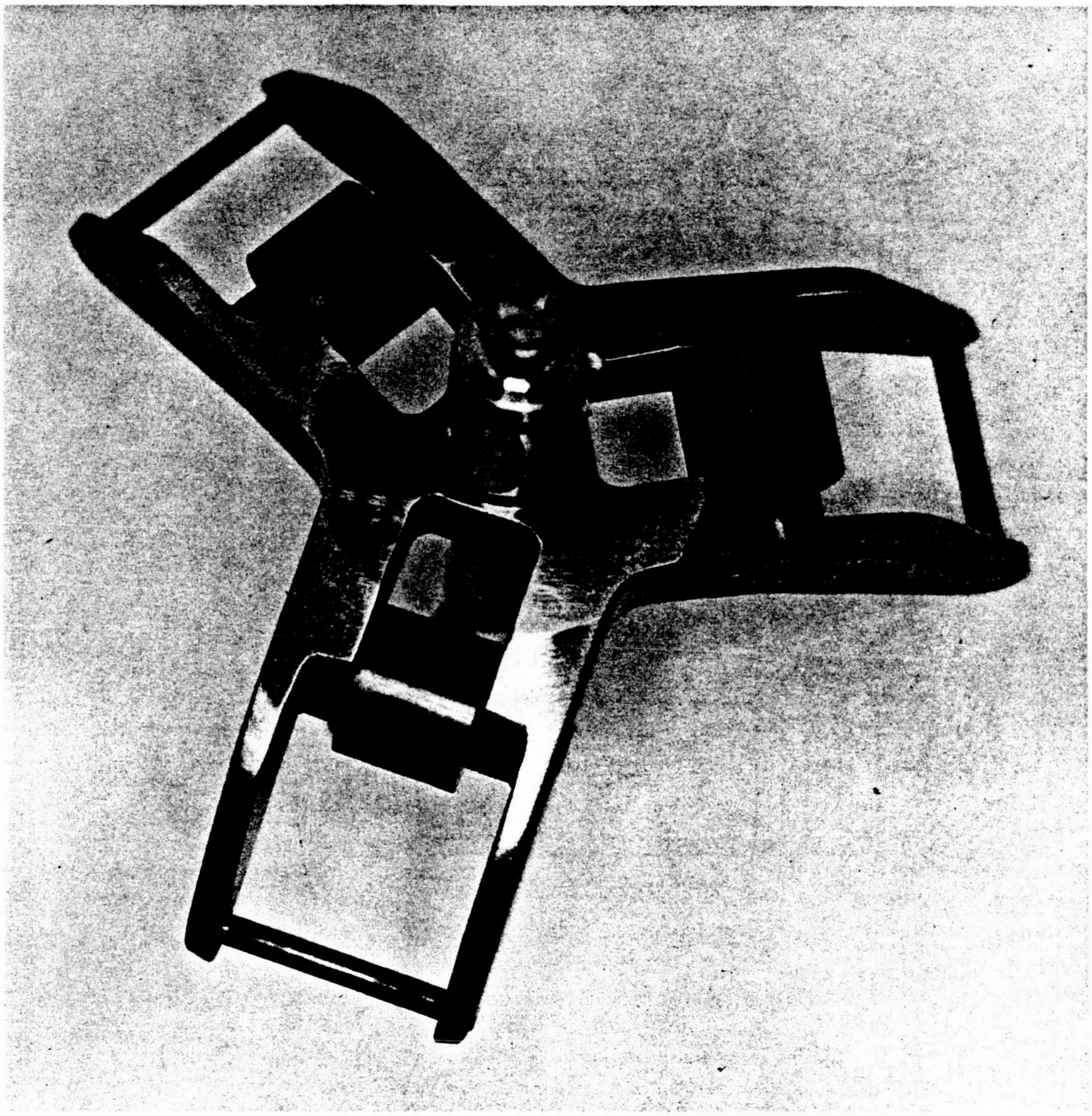


Figure 17.1-7.- Spider assembly.

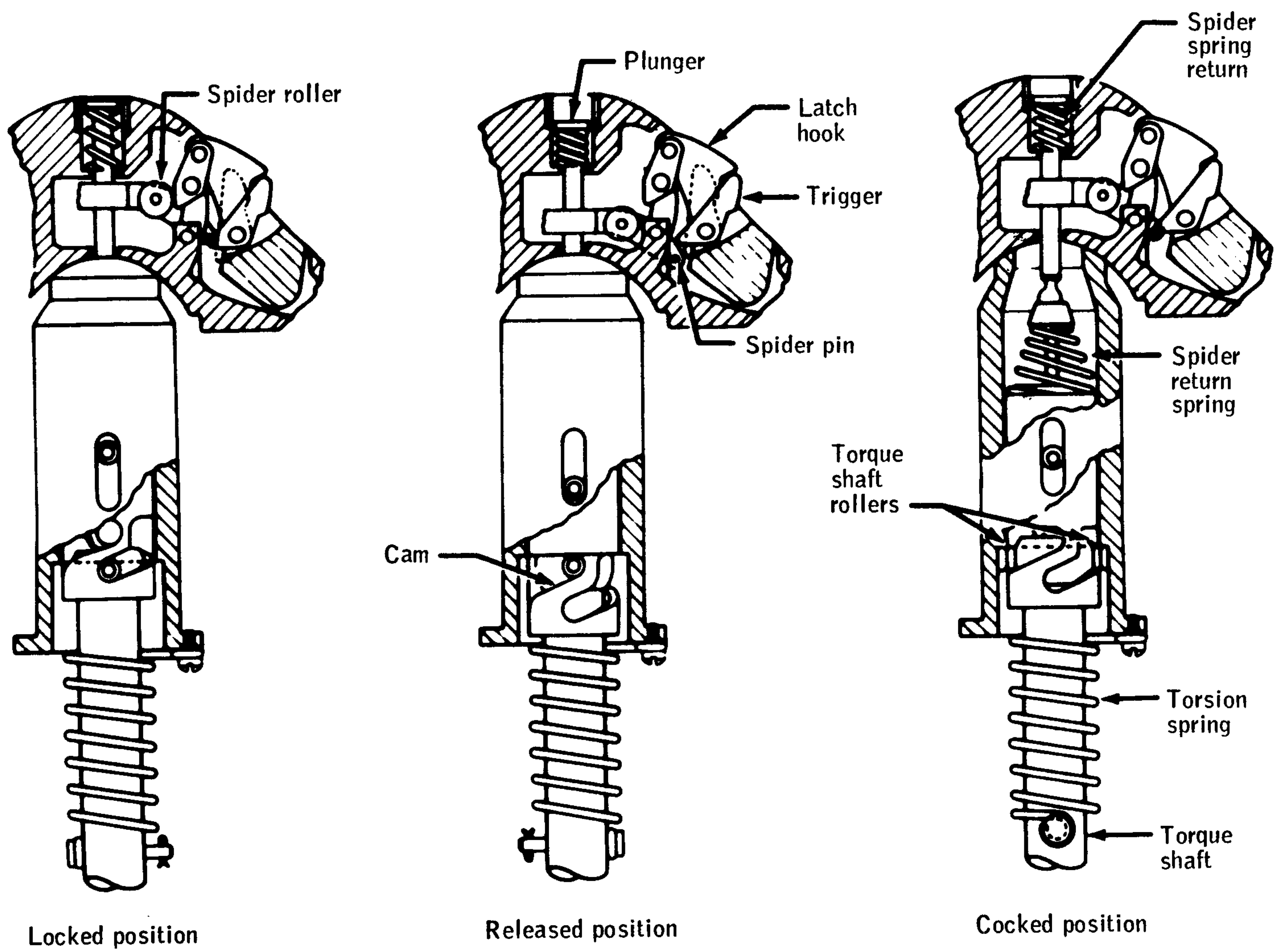


Figure 17.1-8.- Relationship of probe latch and cam mechanism.

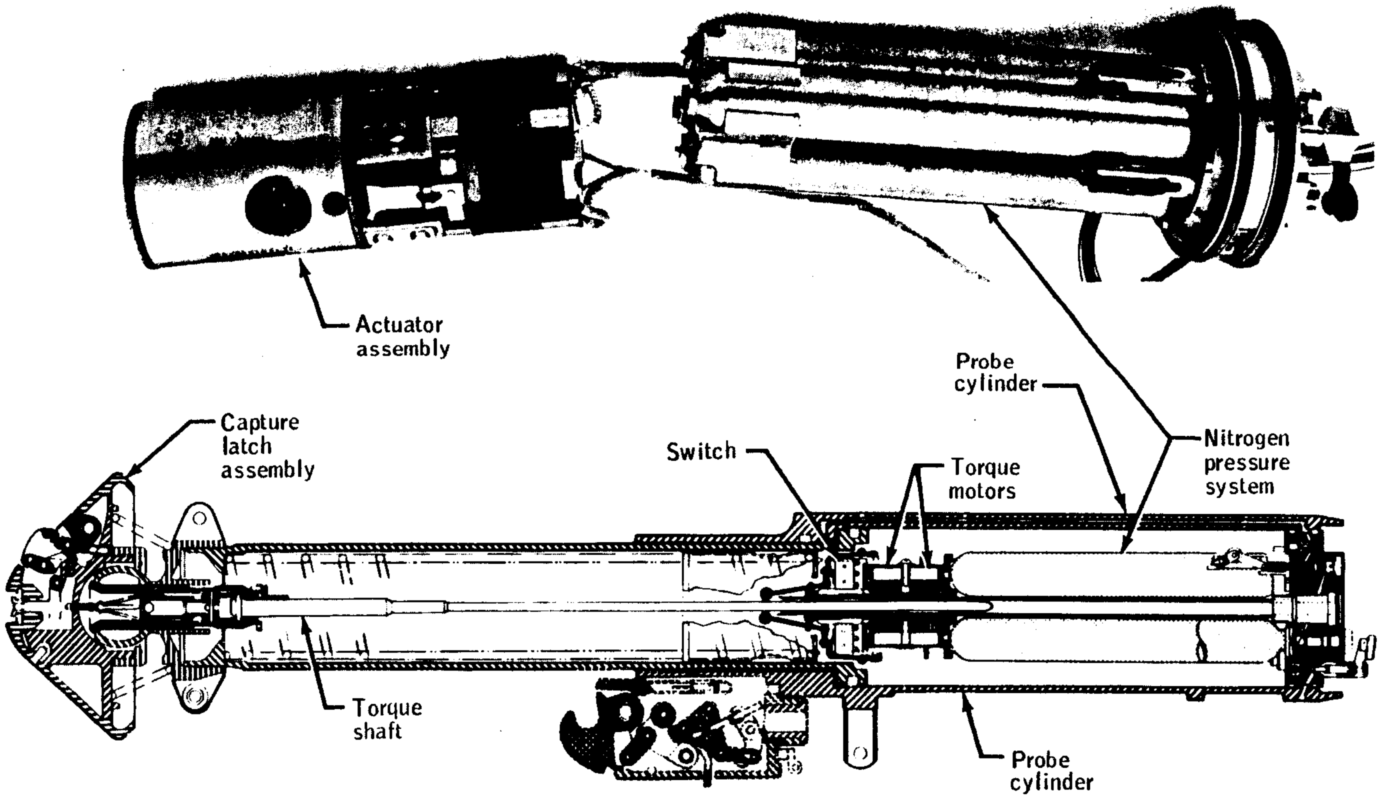


Figure 17.1-9.- Cocked and extended probe assembly.

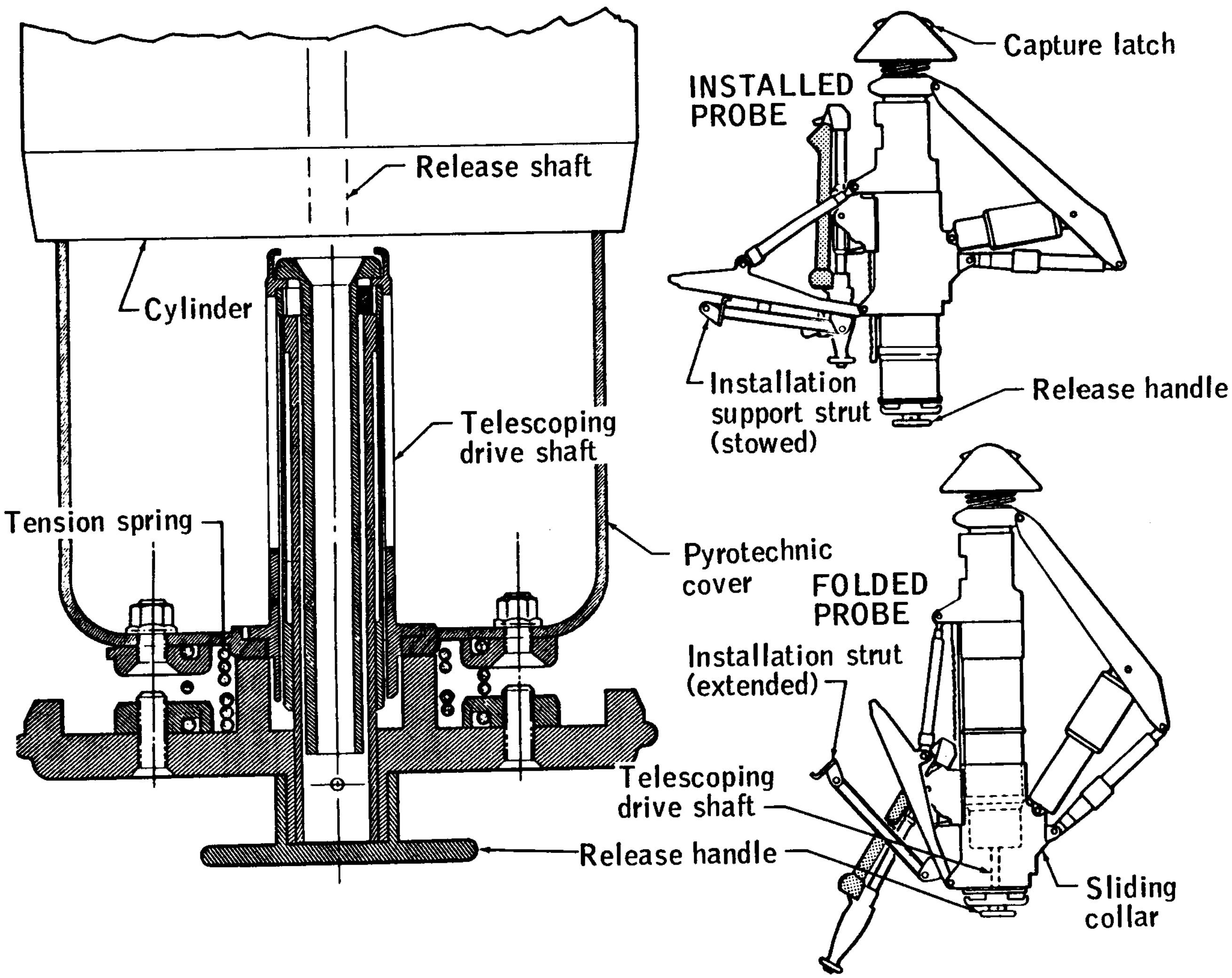


Figure 17.1-10.- Capture latch release.

As the probe is folded, the sliding collar travels aft, contacts the release handle, and extends the telescoping drive shaft. The handle is then accessible for manual rotation to release the capture latches.

Should the docking probe be retracted with the capture latches in the cocked position, the torque shaft will not be properly indexed with the keyed female telescoping drive shaft. This would result in damage to the torque shaft and possibly to the command module forward hatch ablator. Since the emergency docking procedure requires retracting the probe with the capture latches in the cocked position, the pyrotechnic cover was removed before attempting this procedure. Cover removal requires deprepressurizing the cabin, removing the command module forward hatch, and manually removing of the pyrotechnic cover.

The docking problem was similar to an anomaly that occurred on the Apollo 14 mission. Although no data are available for the first visit vehicle problem, an assumption was made that the docking contact conditions were such that capture should have occurred.

A power on failure of the latch release motors as well as binding or jamming of the cam, torque shaft, or actuator were eliminated as the failure mode because electrical power data were normal and the crew verified that the torque shaft rotated freely. Based on the crew's observation of the latch configuration following probe removal and the fact that the crew could manually reproduce the anomalous position of the stuck latch hook, the problem was isolated to the probe head. The problem was further isolated to the capture latch hook because there was no apparent binding or stickiness of the capture latch spider, nor could any visible damage or contamination be detected.

Possible causes of the latch malfunction that cannot be eliminated are:

a. Contamination causing binding between the hook and the housing.

b. The slot in the housing may have been wider than the slot in the cap, thereby allowing the hook pin to be trapped (fig. 17.1-11). During inspection of the command module 117 docking assembly, this condition was noted.

The following changes have been implemented for the second visit vehicle and subsequent docking probes:

a. Dimensional tolerances for the slots in the cap have been changed to eliminate any possibility of overhang.

b. Additional assembly level dimensional and force measurements are being performed.

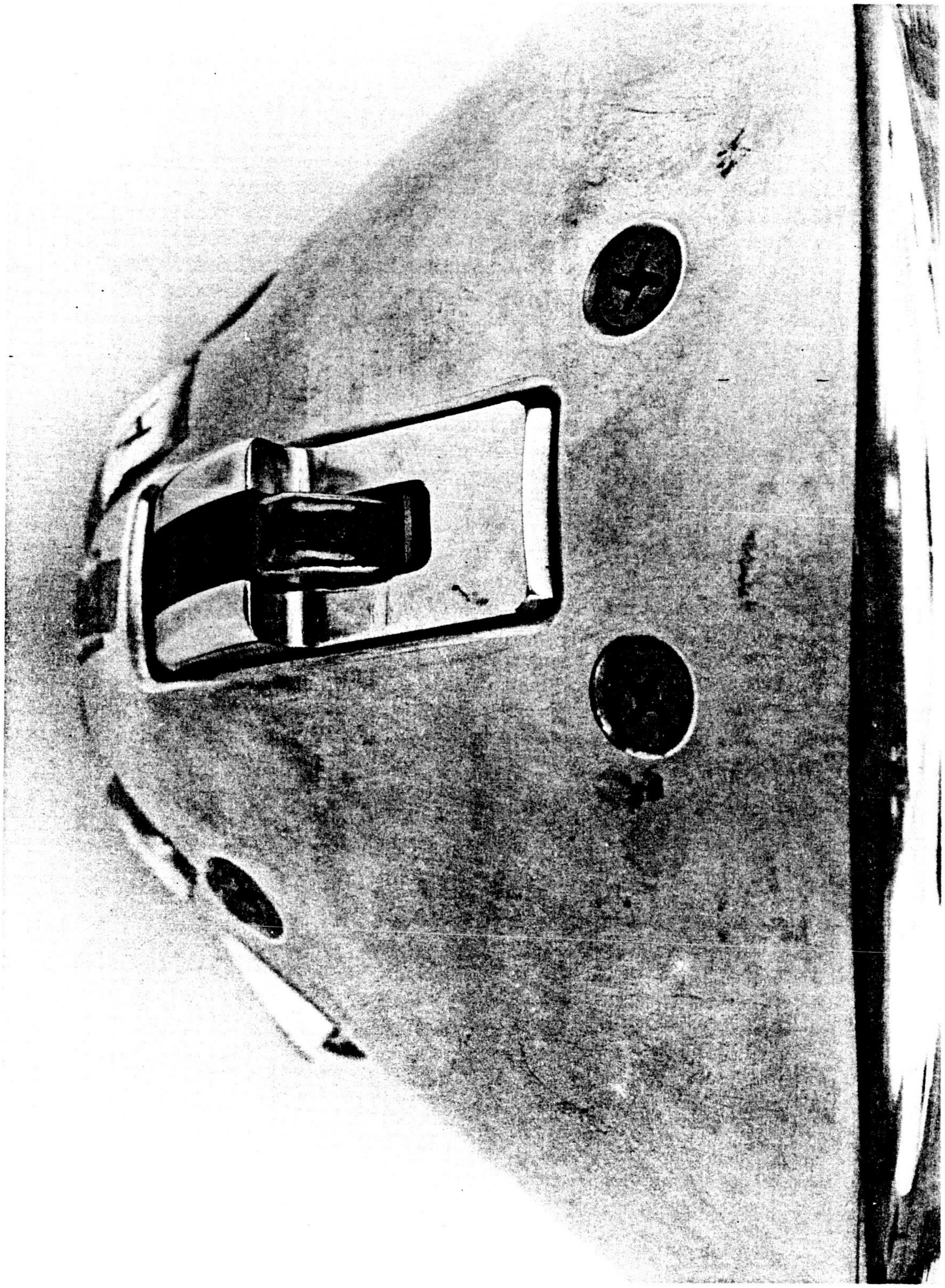


Figure 17.1-11.- Probe cover.

c. Modifications to the pyrotechnic cover to allow emergency docking without requiring command module depressurization for cover removal. This modification consisted of replacing the capture latch release handle with an alignment bushing (fig. 17.1-12) which allows the probe to be retracted without removal of the pyrotechnic cover.

A special tool will also be provided to allow manual rotation of the torque shaft and release of the capture latches.

This anomaly is closed.

17.1.4 Service Module Quad B Engine Temperature Measurement Failed

The service module quad B engine temperature measurement became intermittent on visit day 2 switching between 350° K and off scale high (excess of 428° K) and remained at the off scale high indication 3 hours and 35 minutes later.

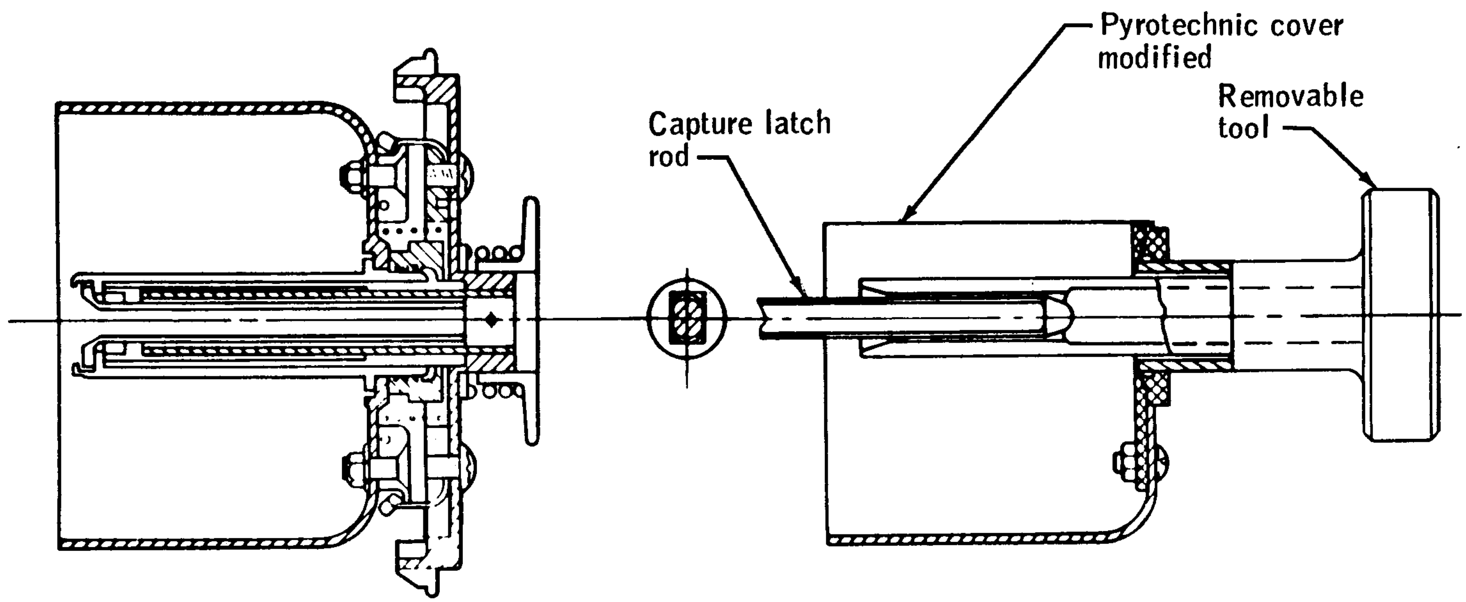
The transducer (fig. 17.1-13) is a platinum resistance thermometer that operates in a resistance bridge. The transducer is connected to the signal conditioner by a twisted shielded four wire cable. Two of the four wires are connected to the resistance thermometer and the remaining two are shorted together to cancel errors introduced by wiring resistance.

The bridge output is amplified by a differential amplifier and supplied to the instrumentation system. The negative side of the amplifier output is connected to the signal ground of the pulse code modulation assembly. The positive output is connected to the multiplexer of the pulse code modulation assembly.

Several possible failures could have occurred. First, the resistance thermometer circuit may have become open. If this occurred, the resistance bridge would have been unbalanced in a direction to cause the off scale high indication.

A second possible failure is a short to ground in any one of three of the four wires in the twisted shielded quad cable. Such a short would tie the differential amplifier negative output to the negative input through the ground path and drive the amplifier to maximum output, giving the off scale high indication.

The transducer cable shield is connected to ground at the signal conditioner. The shield connection is made by crimping two ferrules around the cable, the first under the shield and the second over the shield. Shorts have previously occurred because the inner ferrule was too small for the wire bundle and cut through the wire insulation during assembly



(a) Present pyrotechnic cover.

(b) Modified pyrotechnic cover and tool.

Figure 17.1-12.- Pyrotechnic cover modifications.

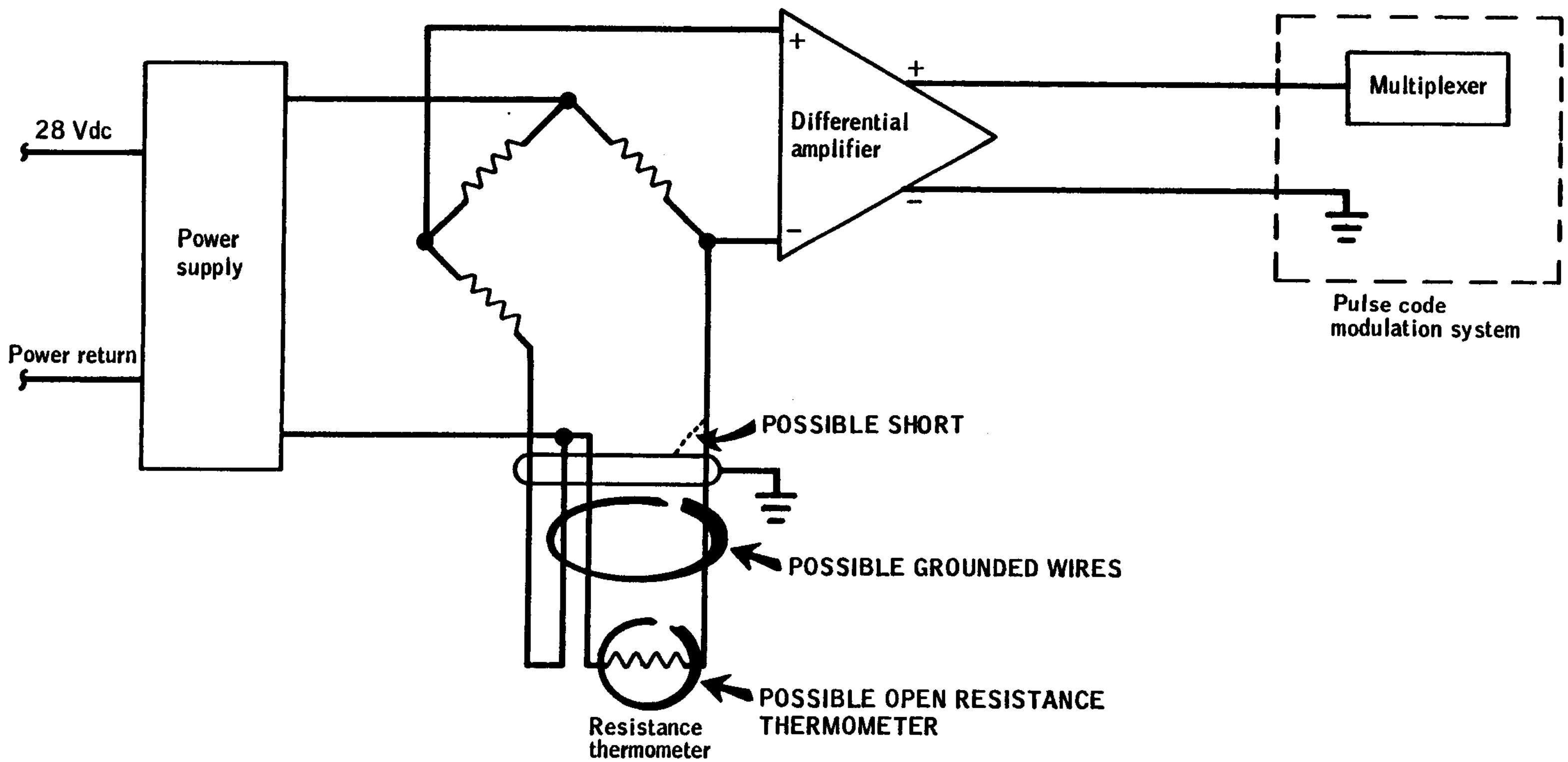


Figure 17.1-13.- Engine temperature measurement circuit.

(fig. 17.1-14). During subsequent operations, the wire conductor shorted to the inner ferrule. When this problem was first identified, the assembly drawing was changed to allow the use of a ferrule having a larger inner diameter. In addition, a post-assembly shield to conductor resistance test was added. The failed quad B transducer was assembled using the small ferrule and was subjected to the resistance test; however, the wire insulation could have been cut through with the conductor positioned in the ferrule in such a manner that a short did not exist when the resistance was measured.

A third possibility is that some failure occurred in the differential amplifier or the portion of the resistance bridge contained in the signal conditioner.

Each service module reaction control system engine quad contains a thermostatically controlled heater which can be used to assure that the engines are hot enough to be safely fired; consequently, no corrective action will be taken.

This anomaly is closed.

17.1.5 Secondary Evaporator Outlet Temperature Read Low

The secondary evaporator outlet temperature measurement failed at 1:01 G.m.t. on visit day 2, when the indication went to 10 percent of full scale low.

The sensor is a copper resistance thermometer encased in a probe that is immersed in the water/glycol coolant. The thermometer is connected as one leg of a bridge circuit which is excited by a 2.7 volt ac power supply. The bridge output is then amplified and rectified by the signal conditioner and supplied to the pulse code modulation system as a 0 to 5 volt dc signal. The signal is also supplied to a cabin meter through a selection switch.

Postflight testing showed a zener diode, which sets the operating point of the signal conditioner ac amplifier, shorted (fig. 17.1-15). Since the ac amplifier stages are all direct coupled, the operating point of each stage was shifted, and the last stage was turned full on. Under these conditions, the amplifier gain was reduced, the waveform was clipped, and the rectified output signal was low.

The diode junction was shorted by conductive contamination inside the diode glass body. The contaminant particle appeared to be a sliver of silicon that had broken off the semiconductor die and migrated to the junction, shorting across the junction. The sliver was fused to the die surface, bridging the junction.

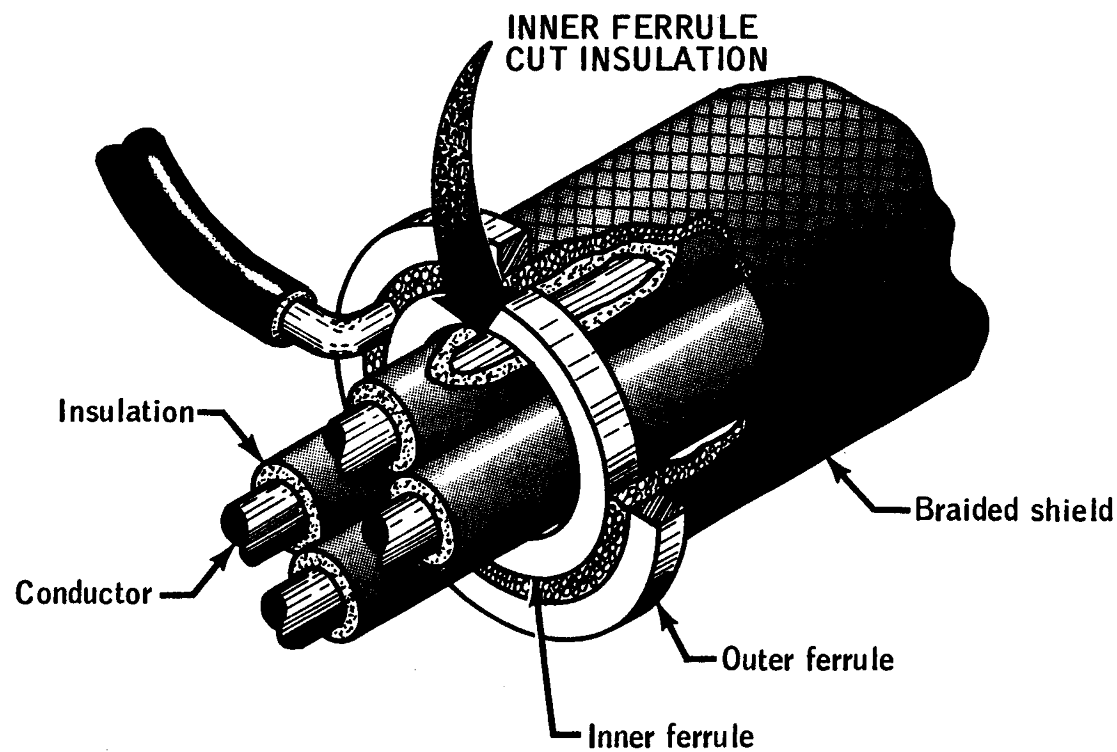


Figure 17.1-14.- Short in wire bundle from conductor to inner ferrule to braided shield.

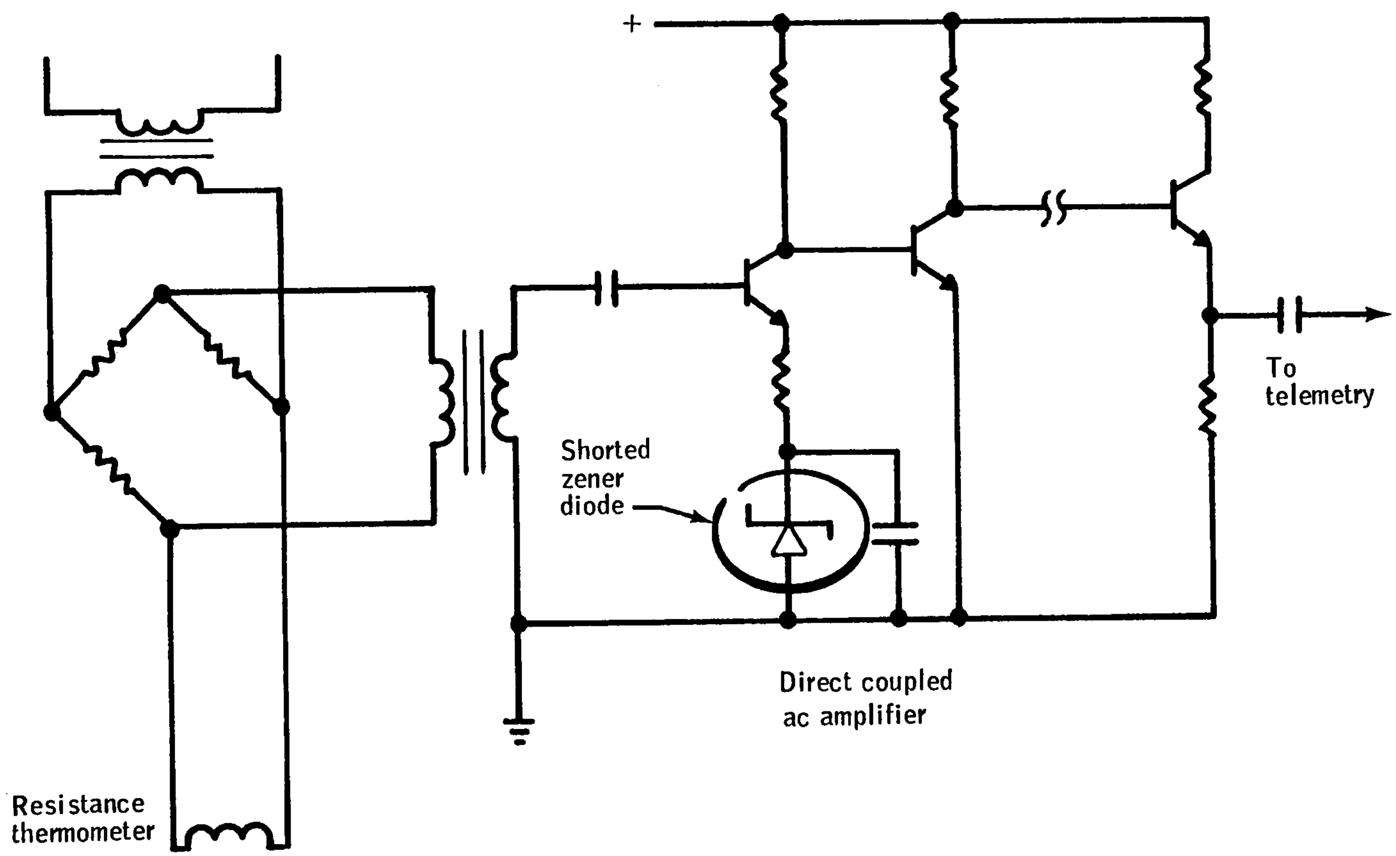


Figure 17.1-15.- Secondary evaporator outlet temperature measurement circuit.

Component screening tests may not detect this type of contaminant since the contaminant sliver may break off of the die at any time, even after the component is assembled into the amplifier; consequently, no corrective action is possible. In any event, since secondary coolant loop performance can be determined by using other measurements. No corrective action is required.

This anomaly is closed.

17.1.6 FM Transmitter Switched Off During Various Uplink Commands

The FM transmitter improperly turned off during command control of the data storage equipment and the S-band power amplifier. All commands performed their intended function and were not affected by this condition. The only abnormal response was the additional operation of the FM transmitter turning off during some specific commands.

The command system uses a six stage register to control 16 select drivers and four set/reset drivers. Each of the 16 select drivers supplies a ground to the coils of two magnetic latching relays (fig. 17.1-16). Power is supplied to the relay coils by the four set or reset drivers. The combination of 16 select drivers and four set or reset drivers allows commanding a total of 64 relay coils. Figure 17.1-16 shows the four relays associated with the select 9 and 11 drivers.

The FM transmitter is turned off by sending select 11 and reset 2. The FM transmitter was also improperly turned off when any select command combined with reset 2 was sent.

Postflight testing showed that the steering diode for the set coil of the select 11 set/reset 2 relay was shorted (fig. 17.1-16). As a result of the short, whenever reset 2 and any select command was given, the sneak current path through the shorted diode also reset the select 11 set/reset 2 relay.

Examination of the diode (fig. 17.1-17) showed that the internal S-shaped contact spring was misaligned and the lower loop of the "S" was touching the semiconductor die, shorting out the junction. The diodes were X-rayed for this type of defect before assembly into the equipment but this one was not detected.

Tests of the complete units are designed to detect this type of problem. Vehicle tests for the second and third visits and the Apollo-Soyuz command modules have been modified to assure that none of the diodes associated with critical command system relays are shorted.

This anomaly is closed.

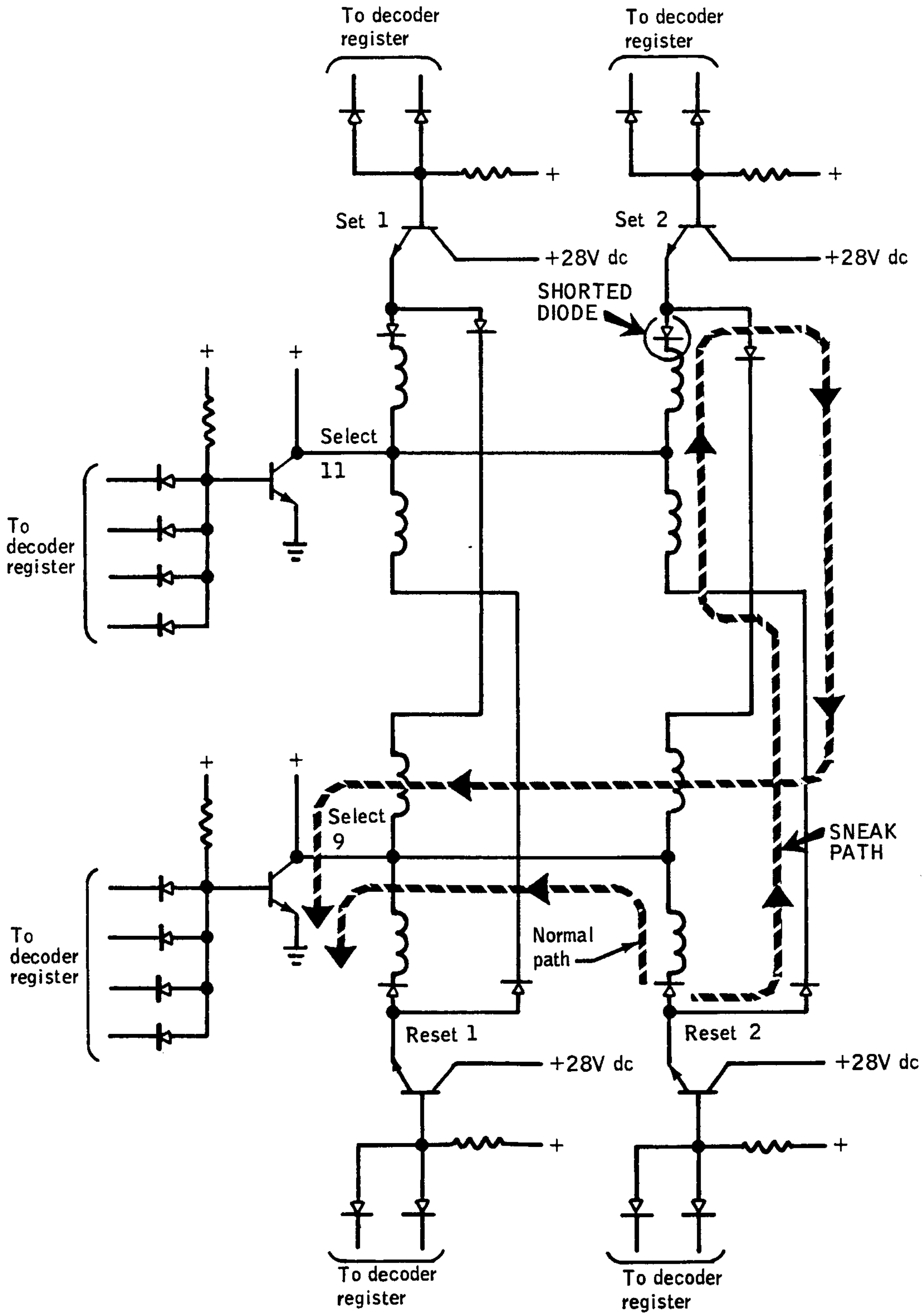


Figure 17.1-16.- Decoder relays.

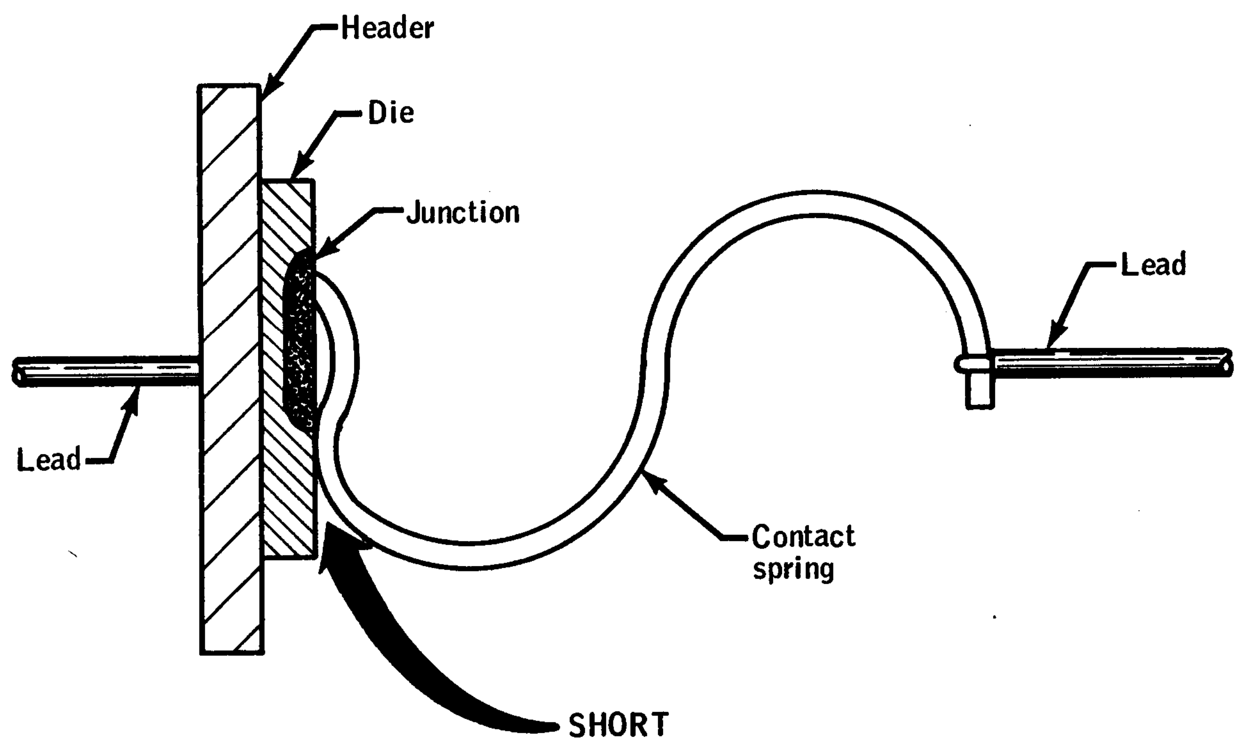


Figure 17.1-17.- Shorted diode.

17.1.7 Secondary Radiator Heater Activated With Controller Turned Off

One secondary radiator heater cycled on while the secondary heater controller switch was off and the secondary radiator inlet and outlet temperature measurements operated while the heater control circuit breaker was opened (fig. 17.1-18).

The primary and secondary coolant loops each have redundant heaters immediately upstream of the service module radiators. The heaters are powered by the service module dc bus. The heater controllers, however, are powered by the command module bus through a circuit breaker and switch, so the controllers can be turned off (fig. 17.1-18).

The two temperature measurements operated while the secondary heater controller switch were off and the associated circuit breaker was open. Consequently, the cycling could not have been caused by a defective switch, circuit breaker, or steering diode. Also, postflight tests showed that the command module wiring was normal, which indicates the problem was in the service module.

The most probable failure was a short between the cathode of the relay spike suppression diode and the contact wiper in one of the two heater control relays (fig. 17.1-18). This was concluded from a controller which was disassembled. The diode lead routing on all relay headers was as shown in figure 17.1-19. Note the marginal clearance between the terminal and diode lead. Assuming a short between the close clearance in this figure, the heater controller would be powered from the service module main bus A (fig. 17.1-18).

The heaters are not needed for the Skylab missions, therefore, the primary and secondary heater fuses have been removed from the second and third visit service modules.

This anomaly is closed.

17.1.8 Reaction Control System Fuel Tank Bladder Torn

The command module reaction control system 1 fuel system had a postflight leak rate of 250 standard cubic centimeters of nitrogen per minute, a significant increase from the preflight test.

The fuel tank was removed from the spacecraft and the postflight decontamination leak was confirmed by an additional test. The bladder was removed from the tank and a visual examination showed a U-shaped cut (or tear) approximately 0.3 centimeters long (fig. 17.1-20). No contaminate that might have caused the cut was found on the bladder or in the tank. The standpipe and tank were also examined for surface irregularities and were smooth.

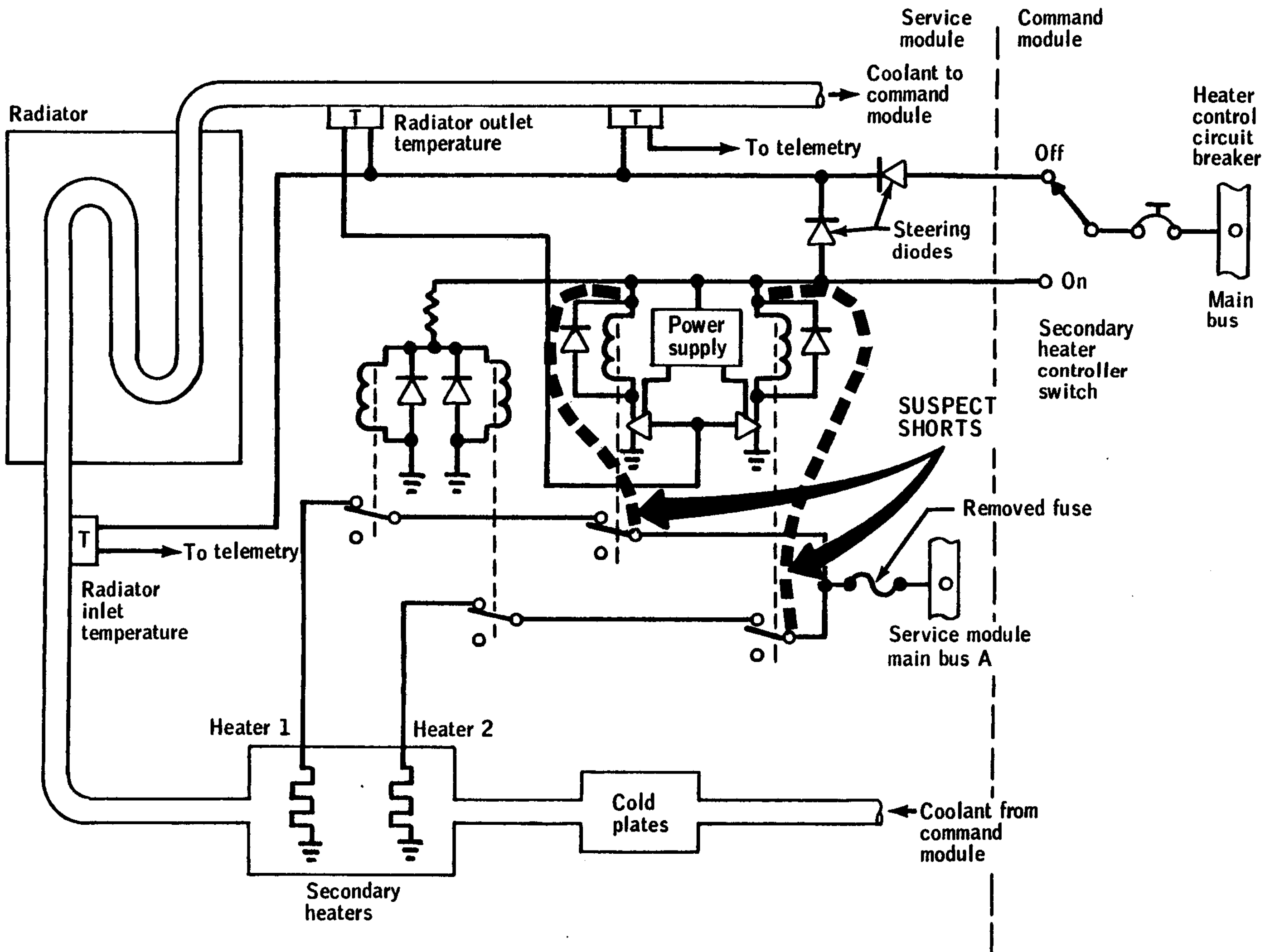


Figure 17.1-18.- Secondary radiator heater control circuit.

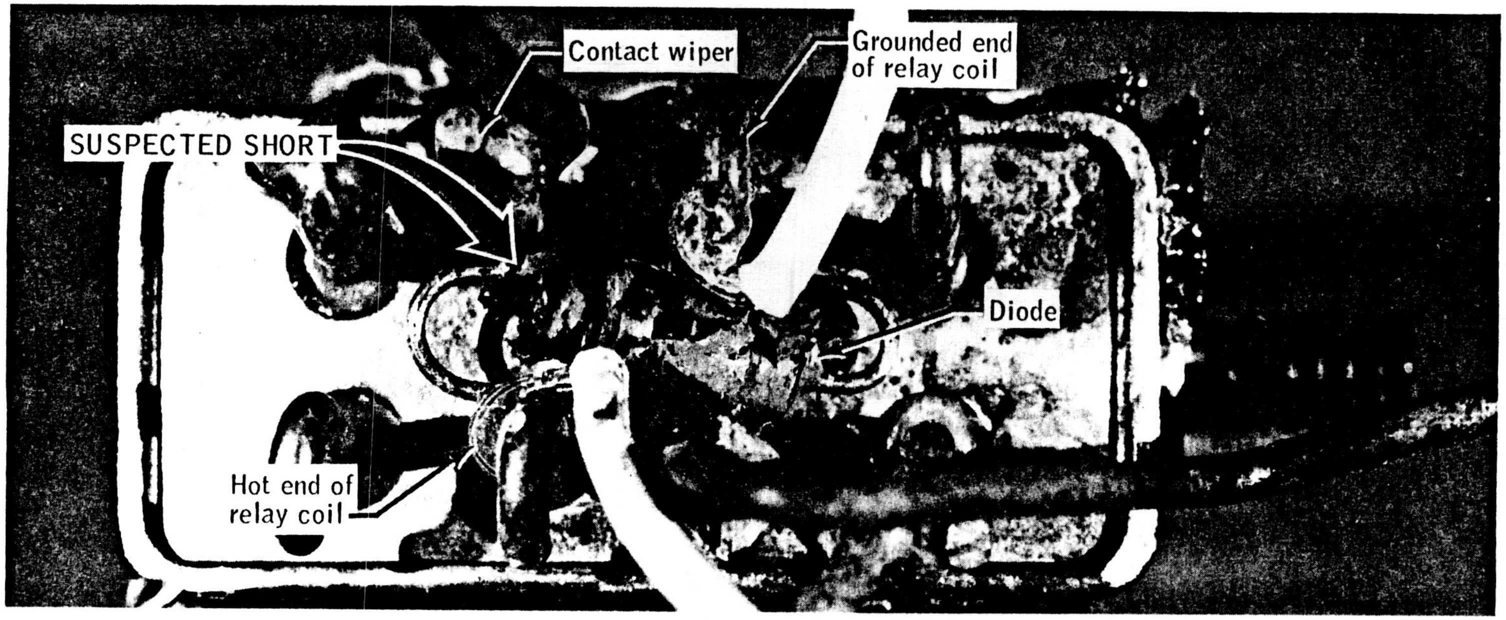


Figure 17.1-19.- Relay header.

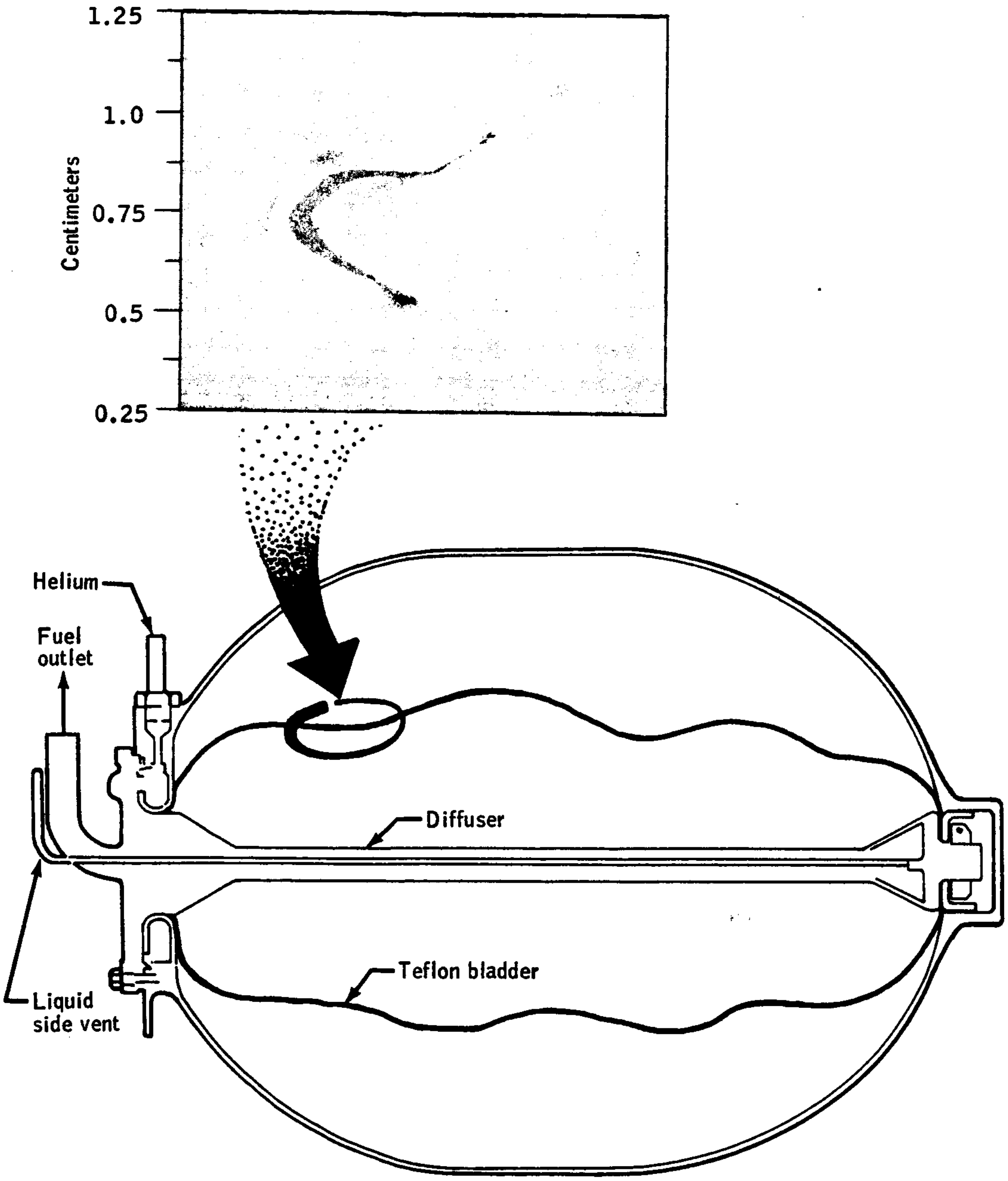


Figure 17.1-20.- Torn bladder in reaction control system fuel tank.

The cause of the tear is unknown. A possible cause is straightening of a three corner fold during fill, entry, landing or deservicing. However, the tank performance during flight operations and postflight offloading was completely normal. If the hole existed before the flight, system operation would not have been affected since there is virtually no differential pressure across the bladder. Therefore, there is no reason for the fluid to move out of the bladder except for some capillary action. No fluid was found in the helium during fill or deservicing operations.

No corrective action is required.

This anomaly is closed.

17.1.9 Recovery Helicopter Struck by Drogue Parachute Reefing Line

The recovery helicopters entered the fall out pattern of the debris resulting from the command module entry before all debris had reached the ocean surface. A 3 meter section of drogue parachute reefing line impacted the main rotor blade of one of the helicopters and was found draped over a landing gear strut when the helicopter returned to the aircraft carrier.

An impact time analysis has been performed for all debris generated during entry. The following table shows the latest time of landing for all debris which is still in the air after command module landing.

Item[a]	Time to landing after command module landing, min:sec
Drogue parachute deployment bags (2)	10:17
Drogue parachute reefing lines each 3.4 meters long (8)	10:50
Drogue parachutes (2)	9:02
Pilot parachute bags (3)	2:45

[a]Number of each type of item in parentheses.

As a result of the analysis, recovery procedures are being modified to prevent helicopter entry into the debris fall out pattern until all pieces which could damage the helicopters have impacted the water.

This anomaly is closed.

17.1.10 Erroneous Trunnion Angle Indications

Three times during the visit, the command module computer sextant trunnion angle position information was in error. All three times, the optical loop was in the optics zero mode, and both the shaft and trunnion angles in the computer should have read zero radians. The trunnion errors observed at the three instances were 1/6, 1, and 1/2 radians, respectively. Figure 17.1-21 is a functional diagram of the optics and computer interface. The coupling display unit contains the analog to digital converters which interface the optics with the computer. Resolvers on the shaft and trunnion axes of the sextant provide position signals to the read counter in the coupling display unit. The read counter stores the resolver position data in digital form. Limited data are available for the first occurrence. The second occurrence existed for about five seconds, and the last occurence about 30 seconds.

Attempts were made to use the optics after each of the last two occurrences. The automatic optics positioning routine in the computer pointed the optics in the wrong position because of the error, and the desired stars were not acquired. At this time, the crew observed that the mechanical position counters on the optics panel agreed with the desired angle in the shaft axis from the computer, but did not agree in the trunnion axis. (Once the erroneous information is stored in the computer, the computer retains that data until the optics zero mode is reselected.) The optics zero mode was reselected and the computer and optics were reinitialized. Therefore, the error was removed. Subsequent use of the optics and the automatic positioning routine was normal. In the zero optics mode, the computer issues no drive commands and the sextant shaft and trunnion angles are driven to zero radians using only the positioning electronics. Should the trunnion angle change (fig. 17.1-21) the associated read counter and resolver no longer agree, and a read counter difference signal is generated. The read counter difference signal causes the read counter to increment or decrement until the angle again matches the resolver signal. As the read counter changes, a series of pulses, each equal to 10 arc seconds trunnion angle, is sent to a computer register that stores trunnion angle data. In this way, the computer tracks the optics position changes.

The indications observed in flight must have been caused by an intermittent condition which caused sextant trunnion angle changes to be sent to the computer (while the optics was in the zero mode), although no actual change in trunnion angle had occurred. The coupling display unit, the computer, and the wiring harness that could cause the intermittent condition are under test, but performance has been completely normal.

The coupling display unit contains five read counter circuits. Two are used for the sextant position control. The other three are used to transfer the stable platform gimbal angle information to the computer.

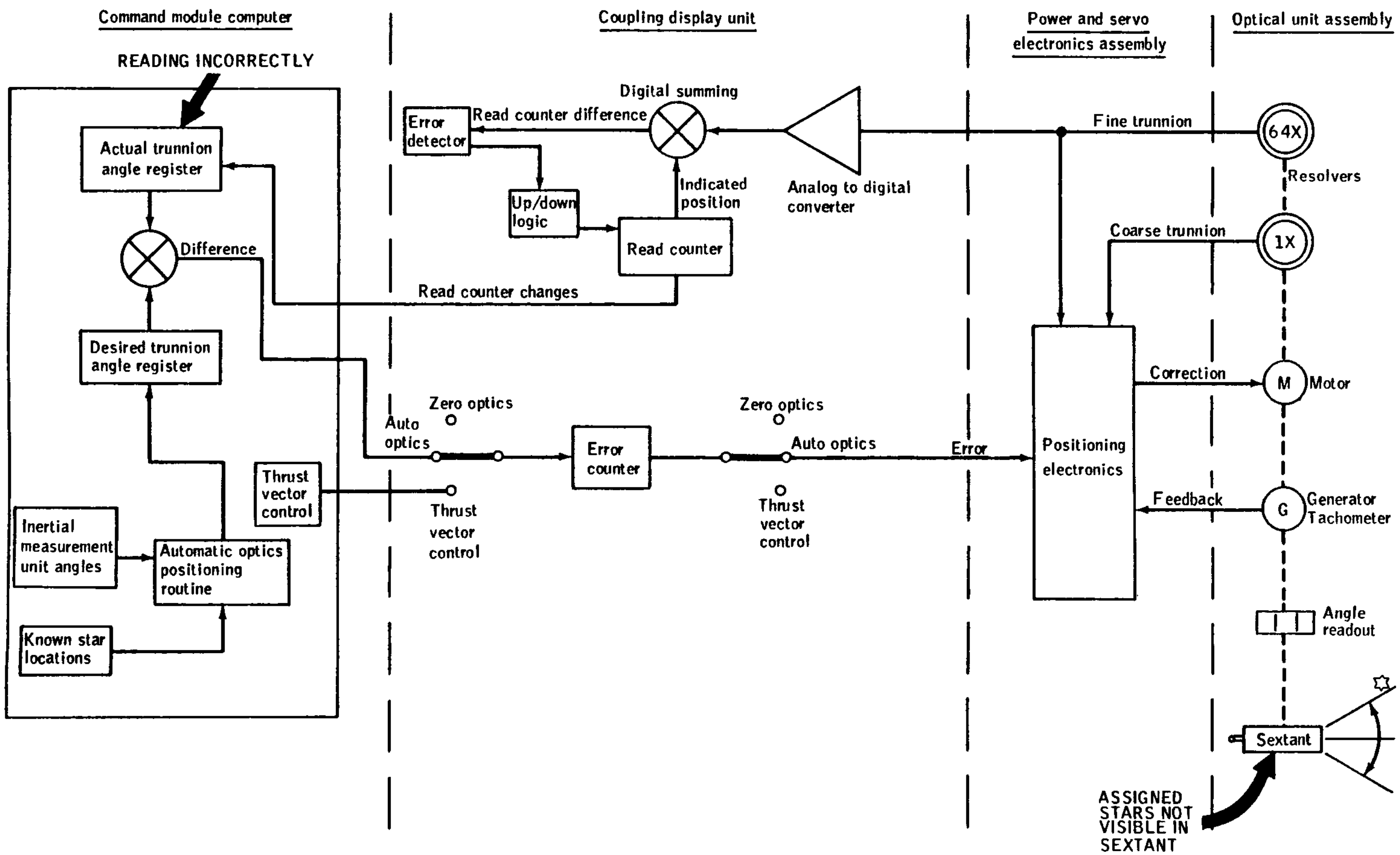


Figure 17.1-21.- Simplified optics - coupling display unit - computer interface (sextant trunnion angle only).

The intermittent condition experienced in flight could occur in any of the five read counters. If the intermittent problem were to occur in one of the three gimbal angle read counters, digital autopilot attitude hold and automatic maneuver capabilities would be lost. Control could be restored after the intermittent disappeared by performing a coupling display unit zero operation and existing malfunction procedures. If the condition were a hard failure, the computer would lose all attitude information in the affected axis. However, existing erasable memory programs could be used that would inhibit the computer from using any information from the affected axis.

Inflight malfunction procedures exist which will identify any of the effects discussed previously. In addition, existing contingency procedure will allow performance of all mission requirements. Therefore, this anomaly is not a constraint for the second visit.

This anomaly is open.

17.2 EXPERIMENT ANOMALIES

17.2.1 Experiment M074 Sample Mass Measurement Device Failed

The sample mass measurement device for experiment M074 in the waste management compartment failed to operate and illuminate its displays on visit day 4.

The purpose of the sample mass measurement device was to measure mass in zero g, to validate the theoretical zero-g behavior of the device, and to support biomedical experiments requiring mass determination. In the device (fig. 17.2-1), the mass to be measured is supported by a leaf spring system which oscillates in simple harmonic motion when loaded and released by the control lever. The frequency of motion is mathematically related to the total mass of the specimen tray, tie down sheet, and specimen.

The electronics module circuitry times the oscillations of the device and displays the readings for later conversion into the mass of the specimen, as well as measuring and displaying the temperature of the device.

The electronics module (fig. 17.2-1) contains the following controls and displays:

a. A three position switch, labeled MASS-OFF-TEMP, that is used to remove power from the module, or select either the mass or temperature measurement modes.

b. A reset button that clears the digital display to prepare for a new measurement.

c. An illuminated digital display for the mass equivalent readings and temperature readings.

The waste management compartment sample mass measurement device was checked out satisfactorily on visit day 3. About 18 hours later, the crew reported that the displays did not illuminate. The reset button was depressed and no reading of mass or temperature was present.

The device had been inadvertently left operating for 16 to 18 hours since the satisfactory checkout. Normally, this would not cause any device problems. However, the electronic module temperature at the time of activation was about 322° K as a result of the thermal condition in the Orbital Workshop. Analysis shows that the temperature of some electronic

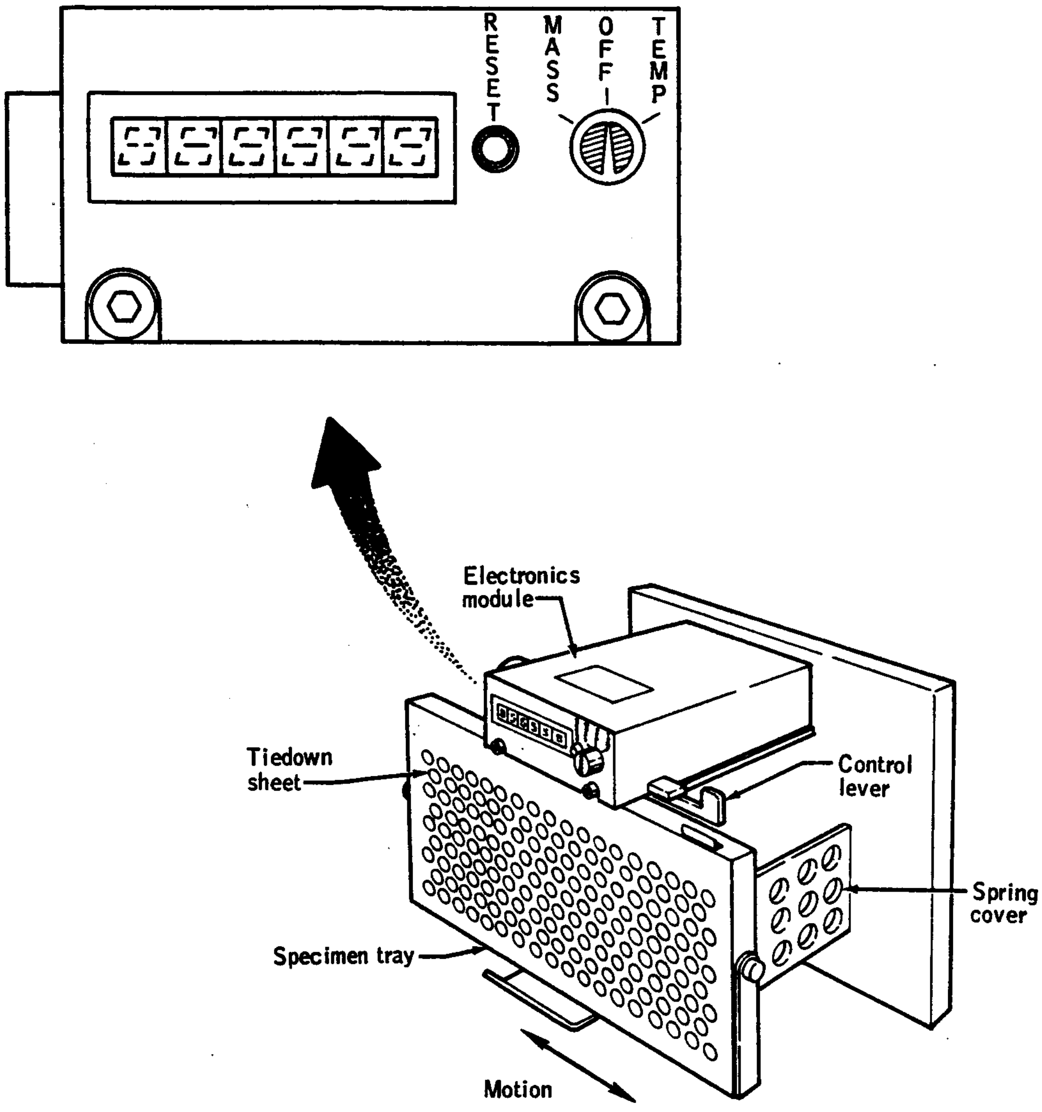


Figure 17.2-1.- Specimen mass measurement device.

components exceeded 366° K because of the constant 15 watt output of the module, and the abnormally high ambient temperatures.

The electronic module in the waste management compartment sample mass measurement device was exchanged with the module in the wardroom sample mass measurement device, and the device operated satisfactorily.

Analysis indicates that the 5 volt power regulator that powers the digital display had failed because of temperatures beyond the survival limits of the solid state electronics.

A replacement electronics module will be provided for the second visit.

This anomaly is closed.

17.2.2 Six Malfunction Lights Illuminated During Experiment S190A Checkout

All six film advance malfunction lights illuminated during the original experiment S190A checkout on visit day 5. Progressively fewer lights illuminated as the film was used until all lights remained off during experiment operation. Subsequently, when the film was reloaded, the lights again came on, and went off progressively one at a time as the film was used. The crew verified during troubleshooting activities that the camera was functioning and the film was moving, even though the film advance malfunction lights were on.

The film motion indication is initiated by the rotation of the supply spool (fig. 17.2-2). This rotation is transferred through linkage and a series of gears into an oscillation of the motion sensor. The motion sensor varies the magnetic field established by the magnetic transducer, thus generating a film motion pulse. If the film motion pulse is not generated after an exposure is made, the associated malfunction light will illuminate. The film must be tight on the supply spool for the supply spool to rotate when film is advanced.

The experiment S190A film is wound on spools and loaded into cassettes, which are then loaded into magazines for use. Once the cassette is loaded into the magazine, the film is held so that it cannot unwind on the spool. Before loading into the magazine, the film leader is taped to the outside of the cassette to prevent it from slipping back into the cassette, however, the spool is free to rotate in the cassette.

All of the film associated with malfunction lights was launched in cassettes which were not loaded into magazines. The spools must have rotated within the cassette permitting the film to loosen prior to cassette loading into the magazine.

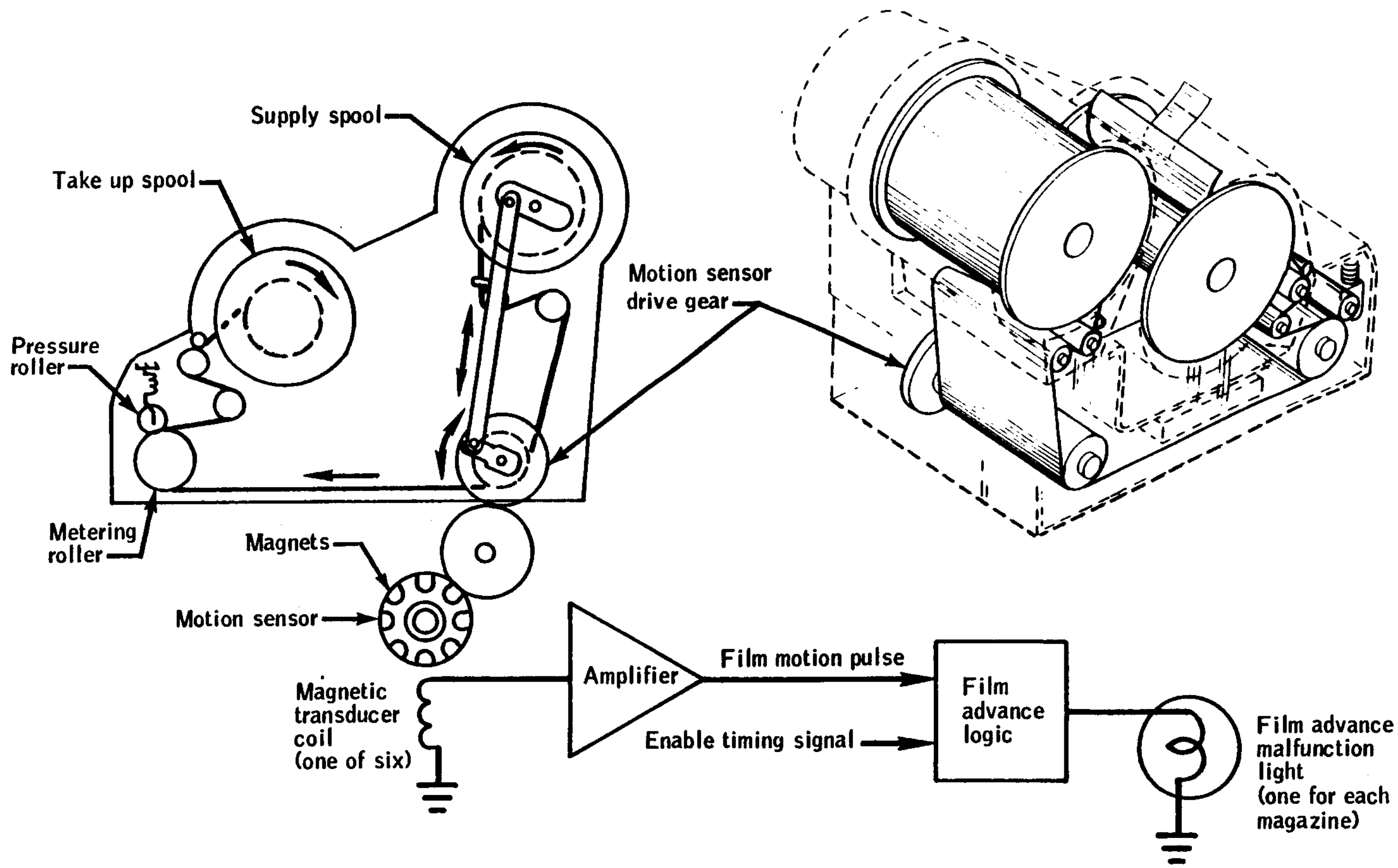


Figure 17.2-2.- Experiment S190A film motion sensing mechanism.

A piece of tape will be placed on the end of each cassette to be carried for the second and third visits to prevent the spool from turning within the cassette.

This anomaly is closed.

17.2.3 Experiment S019 Tilt Control Failed

The articulated mirror system tilt mechanism did not function when the first operation of experiment S019 was attempted on visit day 6. The clutch on the tilt control knob for the articulated mirror appeared to be slipping. One gear of the gear train, which operates the mirror and is visible, did not turn when the control knob was turned.

The tilt mechamism (fig. 17.2-3) consists of a series of shafts and gears which terminate with a ring gear and tangent arm to tilt the mirror through plus or minus 1/4 radian. One of the spur gears in this tilt drive is connected to a seven piece spur gear train that drives a four digit display of tilt angle. The display gear train gear ratio is 30 to 1 and this could result in a small force at the display locking the entire gear train.

A protective cover was installed over the digital display gear train just prior to stowing the experiment for launch to prevent the digital display numbers from reaching the gears, should the numbers have come loose. The protective cover was made of 0.4 millimeter sheet metal and had tabs bent at right angles to the cover.

The gear box cover was removed during the flight to inspect for the cause of the problem. The protective cover interfered with the gear clamp screw (fig. 17.2-4). The cover was straightened and the tilt mechanism then functioned normally.

This anomaly is closed.

17.2.4 Earth Resources Experiment Package Tape Recorder 2 Tape Motion Light

The tape motion light did not illuminate properly for approximately 10 seconds after commanding the tape recorder to change the recording tape speed from 19 to 152.4 centimeters per second during the third Earth Resources Experiment Package data pass. In a 44 second period subsequent to the 10 second period, the tape motion light flickered, dimmed, and then went off; the light then came on for the remainder of the second experiment S192 recording interval. The approximate recording time interval for this period was 1 minute and 10 seconds.

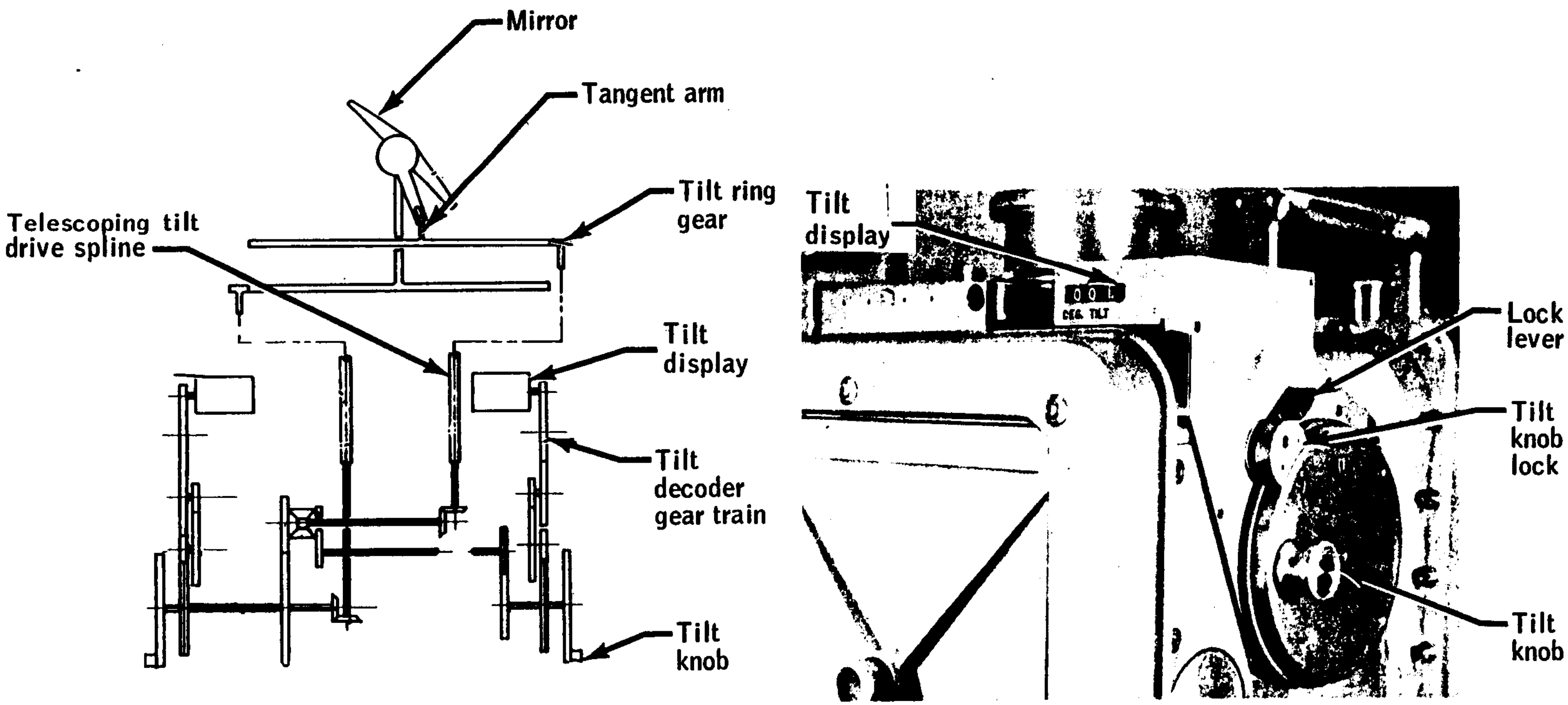


Figure 17.2-3.- Experiment S019 mirror tilt mechanism.

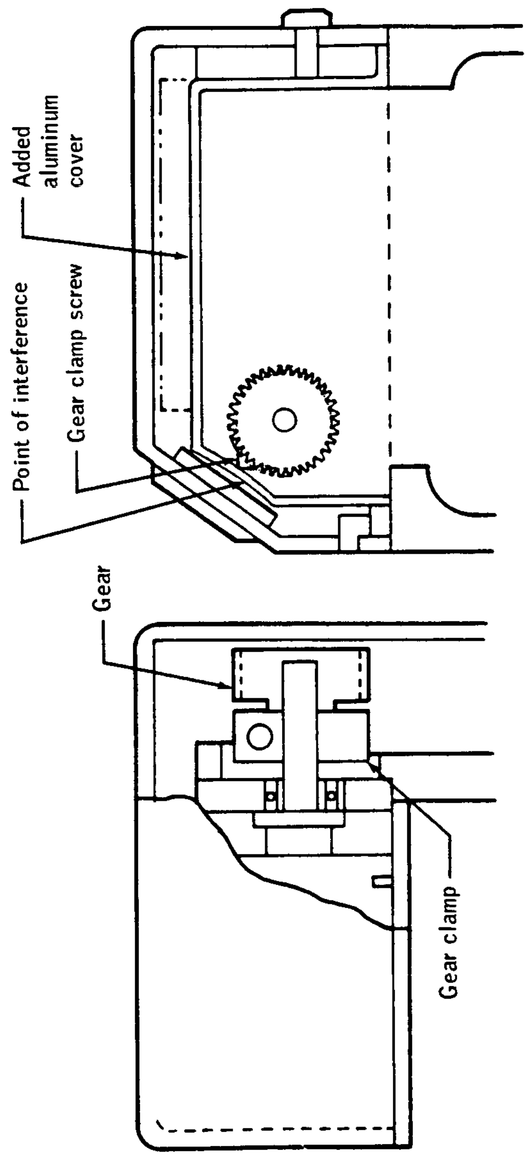


Figure 17.2-4.- Experiment S019 mirror tilt gear train interference.

The tape motion light, 35 seconds after commanding a recording speed transition from 19 to 152.4 centimeters per second and achieving speed stabilization during the fourth data pass, blinked off for approximately 4 seconds and on for approximately 20 seconds during 30 seconds of the second recording interval. The light then remained on for the remainder of the recording interval. The recording interval involved was approximately 1 minute and 23 seconds. As a result of these irregularities, subsequent data were recorded on tape recorder 1.

The tape motion light should illuminate within 5 seconds after initiation of a tape speed transition command during normal operation. The light may blink during the 5 second speed transition period, but should remain on after indicating the proper tape speed.

The tape recorder consists of a tape transport and control and signal processing circuitry (fig. 17.2-5). The tape recorder control logic receives commands from the control and display panel, and in turn, controls the functions of the reel servos, the capstan servo, and the pinch rollers.

Tape speed is controlled by a servo-controlled capstan. The capstan servo receives a signal that is generated by a tachometer disc. The capstan servo compares the tachometer signal frequency with a reference signal supplied by a crystal controlled oscillator. Differences between these two signals correct the capstan rotational speed such that the frequency and phase of the tachometer and reference signals are locked together. Since the tape is clamped against the capstan by pinch rollers whenever the tape is moved; the tape speed is precisely controlled by the rotational speed of the capstan.

The basic requirement of phase lock synchronization (figs. 17.2-6 and 17.2-7) is that exactly one tachometer pulse occurs between two reference pulses. When this state is achieved, a ramp signal is generated. The ramp begins with the reference pulse and terminates with the tachometer pulse. At the termination time, the ramp voltage is sampled by a sample and hold circuit. The sample and hold circuit output voltage is proportional to the phase error between the reference frequency and the tachometer frequency, and is used to control the capstan drive motor speed. The phase offset is adjusted to time center the tachometer pulses between the reference pulses. Under initial starting or slow running conditions, the phase error voltage is high, causing the capstan to speed up until tachometer pulses occur between reference pulses. For overspeed conditions, the phase error voltage remains low, causing the capstan motor to slow down.

The tape motion light circuitry monitors the phase error voltage. At 152.4 centimeters per second tape speed, the tape motion light goes

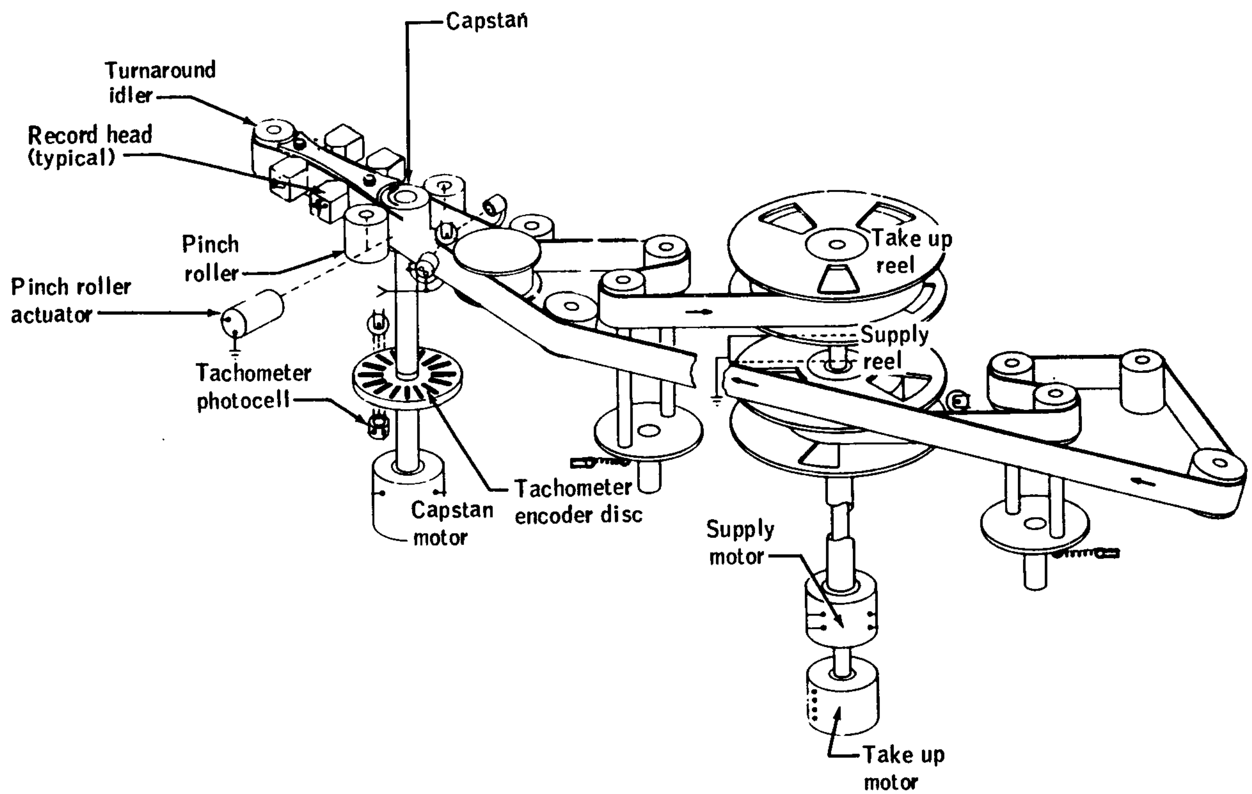


Figure 17.2-5.- Tape recorder transport system

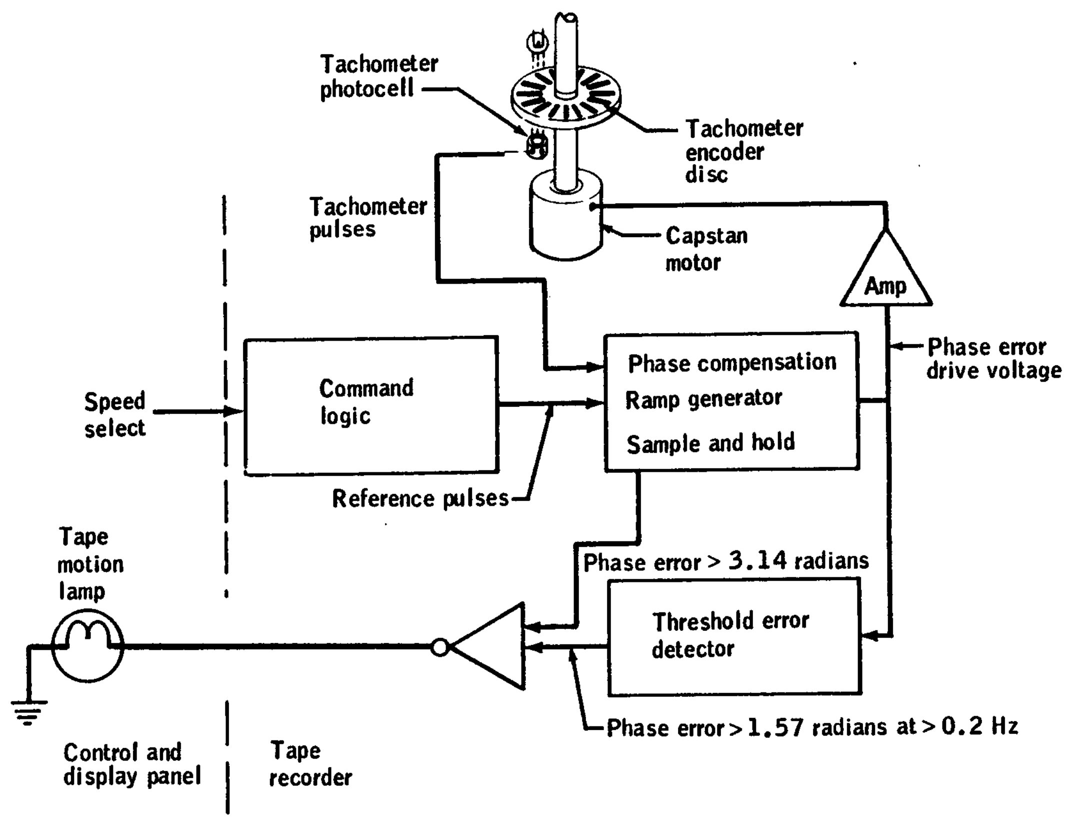


Figure 17.2-6.- Tape motion light circuit.

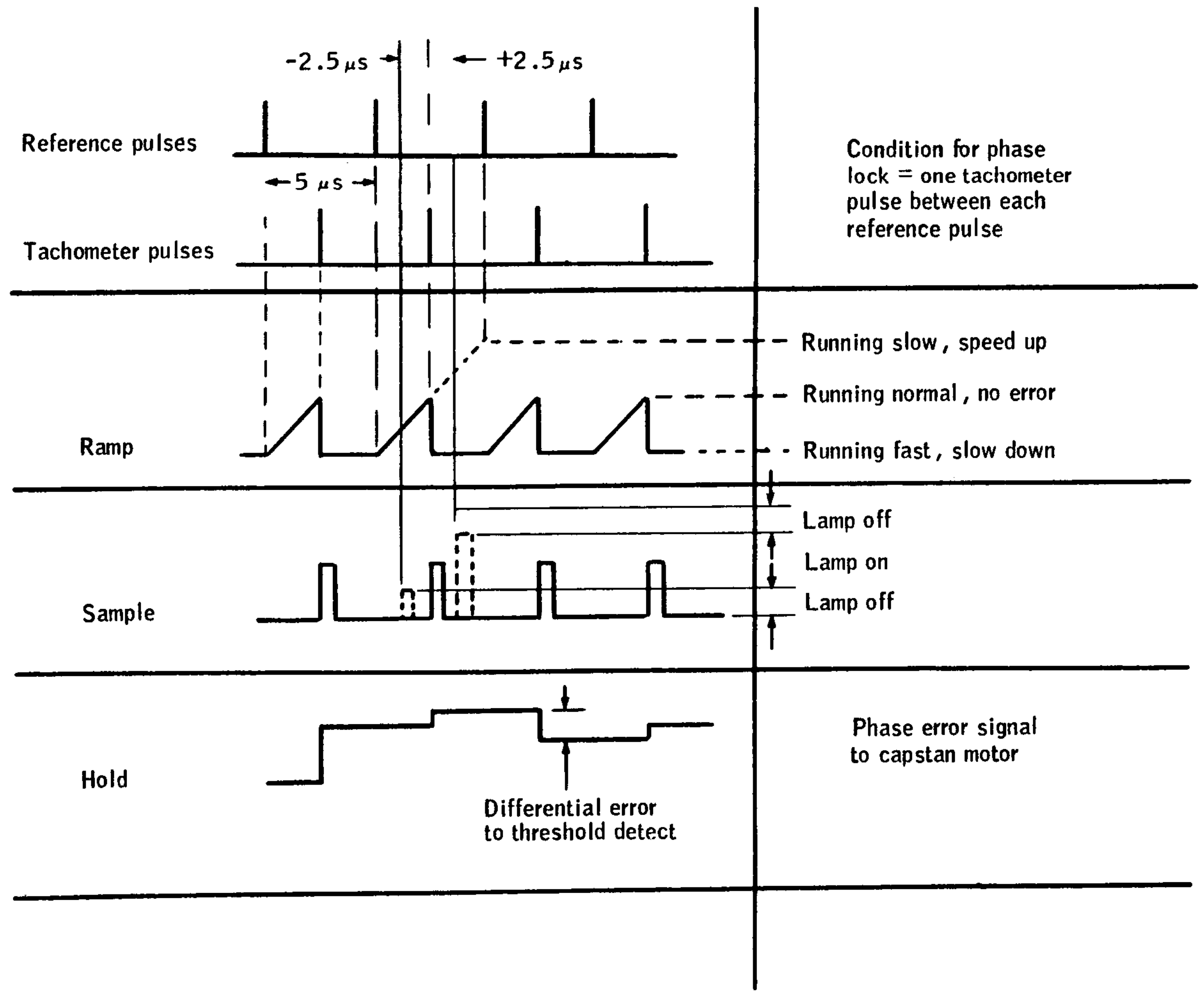


Figure 17.2-7.- Tape motion light waveforms.

off, if the phase error exceeds 3.14 radians steady state (phase slipping) or if the phase error is varying at a frequency greater than 0.2 hertz and the peaks exceed 1.57 radians phase difference.

The increased phase error implied by the intermittent blinking tape motion light is characteristic of a slight and erratic increase in frictional drag which causes a small and erratic variation in capstan drive motor speed.

All returned flight tapes were examined visually prior to rewinding and reproduction. Four of the six tapes showed evidence of binder breakdown, leading to excessive layer to layer adhesion and production of tacky residue. This condition has been observed previously during environmental tape testing in the 323° and 328° K range. Temperatures in the Orbital Workshop in the vicinity of the tape stowage area were in the 318° to 321° K range, but exposure times were greater than those used in environmental testing, and probably caused the tape degradation.

Tape recorder speed variations were displayed and recorded using the tape recorded during passes 3 and 4. The data indicates bursts of flutter (in excess of 1 percent) just before the crew comment times. Two flutter frequencies are present throughout the tape. These are a high frequency flutter (100 Hz range) and a low frequency flutter (5 Hz range). During flutter bursts, only the high frequency increases in amplitude. There are no tape transport rotating components which would generate the high frequency, but the bursts would cause the reported motion light dimming. Also, the erratic nature of the bursts is characteristic of erratic frictional drag from the magnetic tape. The relatively low amplitude of the high frequency flutter would only occasionally, if at all, affect the recovery of recorded data.

The increase in tape speed flutter as a function of the tape used during data passes 3 and 4 indicates that cleaning the tape recorder head at the end of each data pass was effective in preventing data loss. The fact that the primary (no. 1) tape recorder did not also produce an abnormal tape motion light probably results from the differences between recorder servo components, friction, and the slight variability in tape tackiness.

The experiment S192 data have been recovered from all 6 tapes with no degradation that can be attributed to tape speed variations.

This anomaly is closed.

17.2.5 Vacuum Leak in Experiment S190B Camera

A hissing sound was reported as coming from the experiment S190B earth terrain camera body during preparations for Earth Resources Experiment Package data pass eight.

The camera magazine (fig. 17.2-8) has small holes in the platen leading to the vacuum reservoir which is an integral part of the platen assembly. The vacuum held the film against the platen and was regulated to 0.07 newtons per square centimeter. The regulation was provided by a circular bellows on the interior surface of the vacuum reservoir and a bleed off orifice, which is vernier adjusted by a needle valve. The vacuum is placed on the reservoir through the vacuum fitting on the magazine. This fitting is a plain smooth tube which inserts into the camera body inner vacuum fitting (fig. 17.2-9) when the magazine is seated and latched in the camera body. The meshing of these two vacuum fittings is accomplished without visual cues because the magazine obscures the view when being inserted into the body cavity. Figure 17.2-10 shows the magazine inserted and latched in the camera body.

The camera body internal vacuum fitting is lined with a chamfered neoprene seal which holds the magazine vacuum tube in a compressive fit. The vacuum tube feeds through the camera body wall and is terminated in the outer vacuum coupling (partially visible in figure 17.2-8. The Orbital Workshop vacuum hose is coupled to the body coupling to produce the vacuum desired at the platen holes.

Four possible sources for a vacuum leak exist inside the camera body. They are the chamfered neoprene seal at the magazine to body interface, the neoprene diaphragm of the regulator, the platen holes and channels under the film, and the bleed off orifice.

The leakage of the neoprene diaphragm is a remote possibility because the diaphragm is covered by a metal disc that protects against possible puncture. The continuous normal leakages through the platen holes and the bleed off orifice are excluded because the fundamental frequency of their venting noise is above the audible range.

The chamfered neoprene seal is the most probable source of a leak, because leaks can occur if the offset tolerance of the magazine vacuum tubes differ greatly from one to the next. This condition was verified in ground testing.

Placing a double shouldered elastic grommet over the magazine vacuum tube was proven to be an effective seal for the case of a tolerance offset.

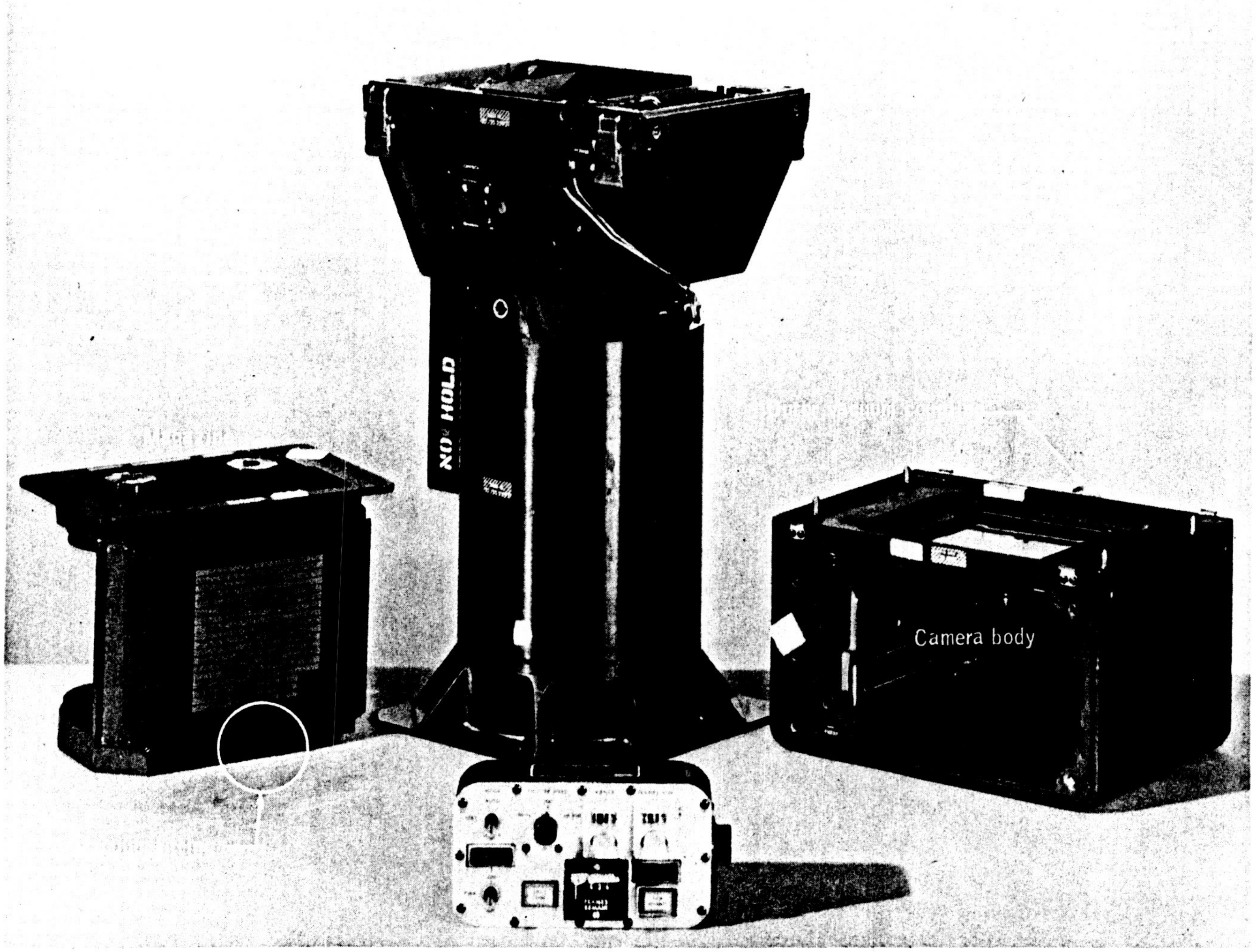


Figure 17.2-8.- Camera components.

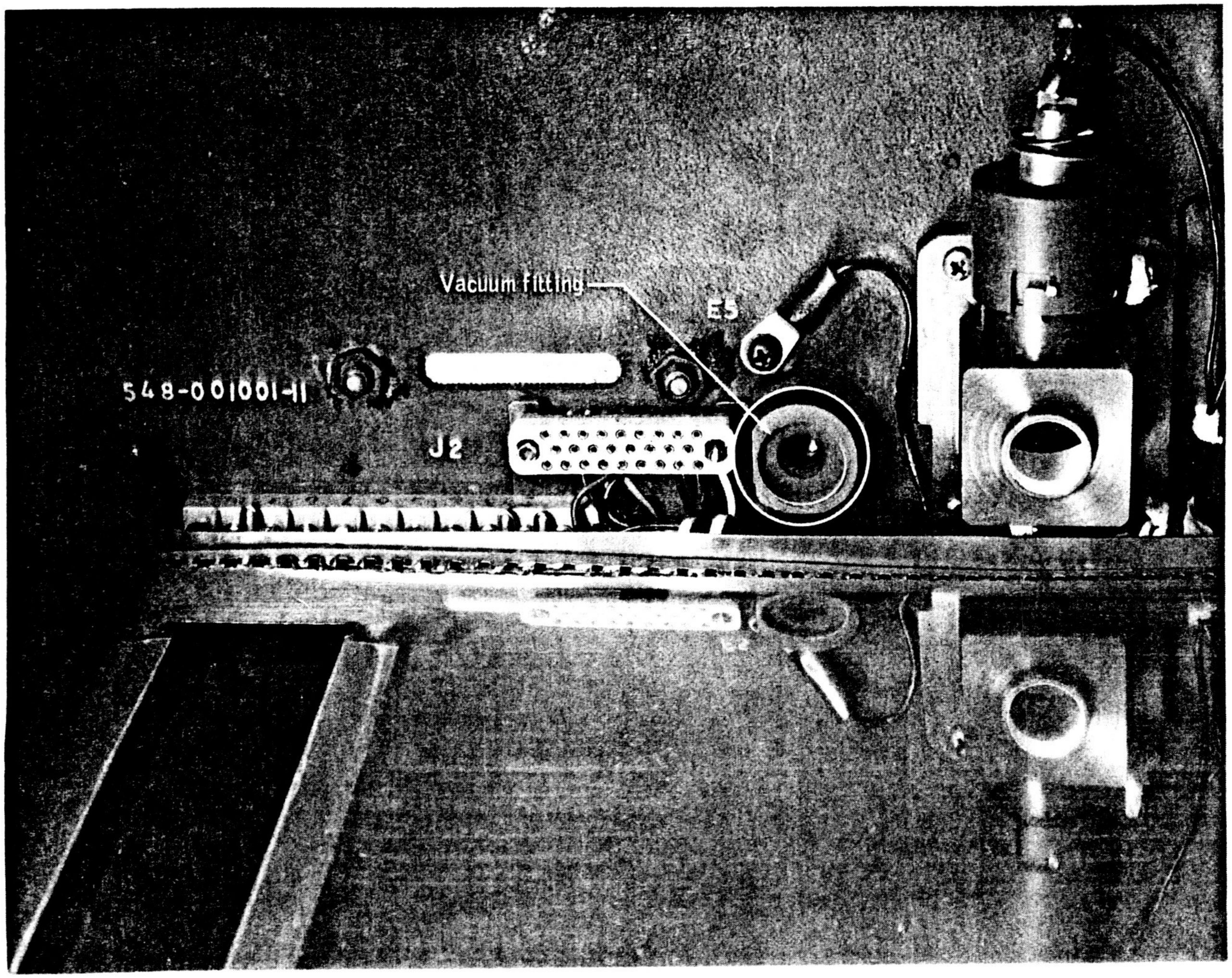


Figure 17.2-9.- Magazine vacuum fitting.

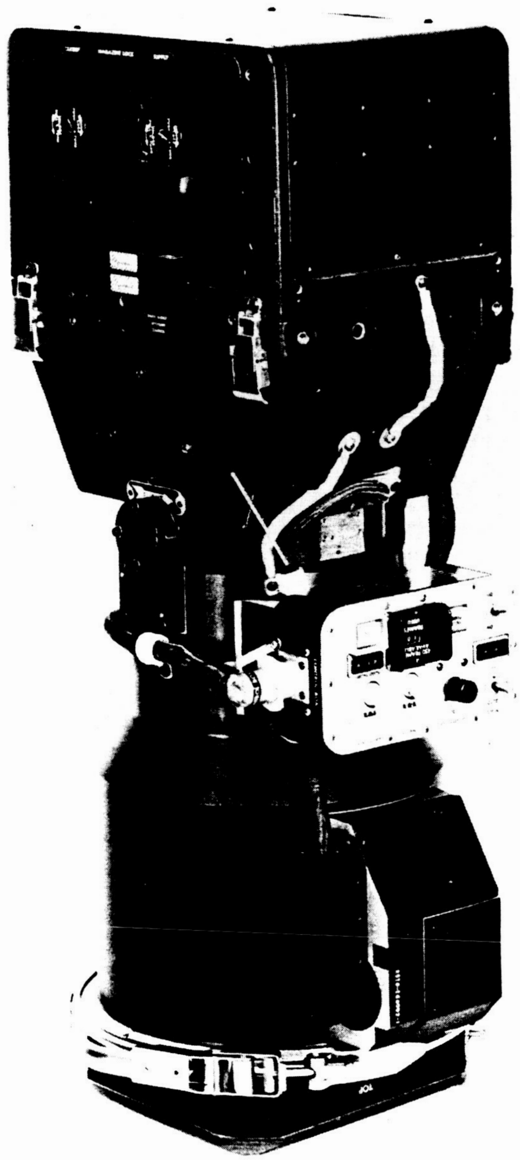


Figure 17.2-10.- Camera and magizine mated.

Three such grommets plus an instruction decal are on the stowage list for the second visit. A copy of the instruction decal (fig. 17.2-11) shows the manner in which the grommet will be installed and seated.

This anomaly is closed.

17.2.6 Sporadic Markings Found On S190A Black and White Film

On the Earth Resources Experiment Package S190A Multispectral Photographic Facility, 12 black and white film rolls had very sporadic and infrequent markings. The film markings are the same type as those observed on other space applications and have been attributed to electrostatic discharges. Photographic film becomes charged by friction due to slippage of the film on itself, transporting film at a slightly different velocity than a roller it may cross, and rubbing against film guides or pressure backs. Film is a poor conductor and builds up and retains its charge in local areas. The charge may slowly dissipate through surface leakage currents, ionize low pressure dry air in the immediate vicinity discharging as a corona, or grounding as a spark to another object.

The coronas and sparks provide free electrons that produce a local photographic effect (exposure) on the film and produce the characteristic streaks, spots, or fork like branches. The local exposure causes some silver ions in the film emulsion to reduce to pure silver, producing dark streaks or spots on the negative on black and white film.

A detailed report on the electrical properties of photographic film may be found in reference 4.

Prior to the first manned visit launch, the overheated air of the Orbital Workshop was dumped to the vacuum of space. As a result, the salt pads in the Orbital Workshop film vault lost most of their moisture and the film became dry.

The most likely place for electrostatic discharging of the film is the metering pressure roller assembly as shown in figure 17.2-12. Both of these rollers have center gaps that match the position of most of the film markings.

The markings were observed on 5 percent of the film frames and were either 2.3 mm wide single or double streaks from 12.7 to 61 centimeters in length. The dual streaks were separated by about 10 millimeters, and figure 17.2-12 shows that this corresponds spatially with roller gaps.

Marking of the film can be caused by friction that charges the film. Charging is usually associated with low moisture content and low atmospheric pressure. The center gaps in two rollers in the magazine provided the transfer edges for the electrostatic discharges.

INSTRUCTION

1. INSTALL SEAL ON SPARE MAGAZINE VACUUM TUBE PER FIGURE A

NOTE:

AFTER THE MAGAZINE HAS BEEN INSTALLED IN THE ETC THE SEAL WILL BE REPOSITIONED SIMILAR TO FIGURE B

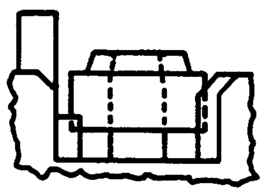


FIG A

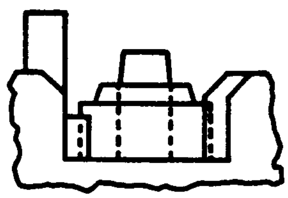


FIG B

Figure 17.2-11.- Decal for modifying camera on future visits.

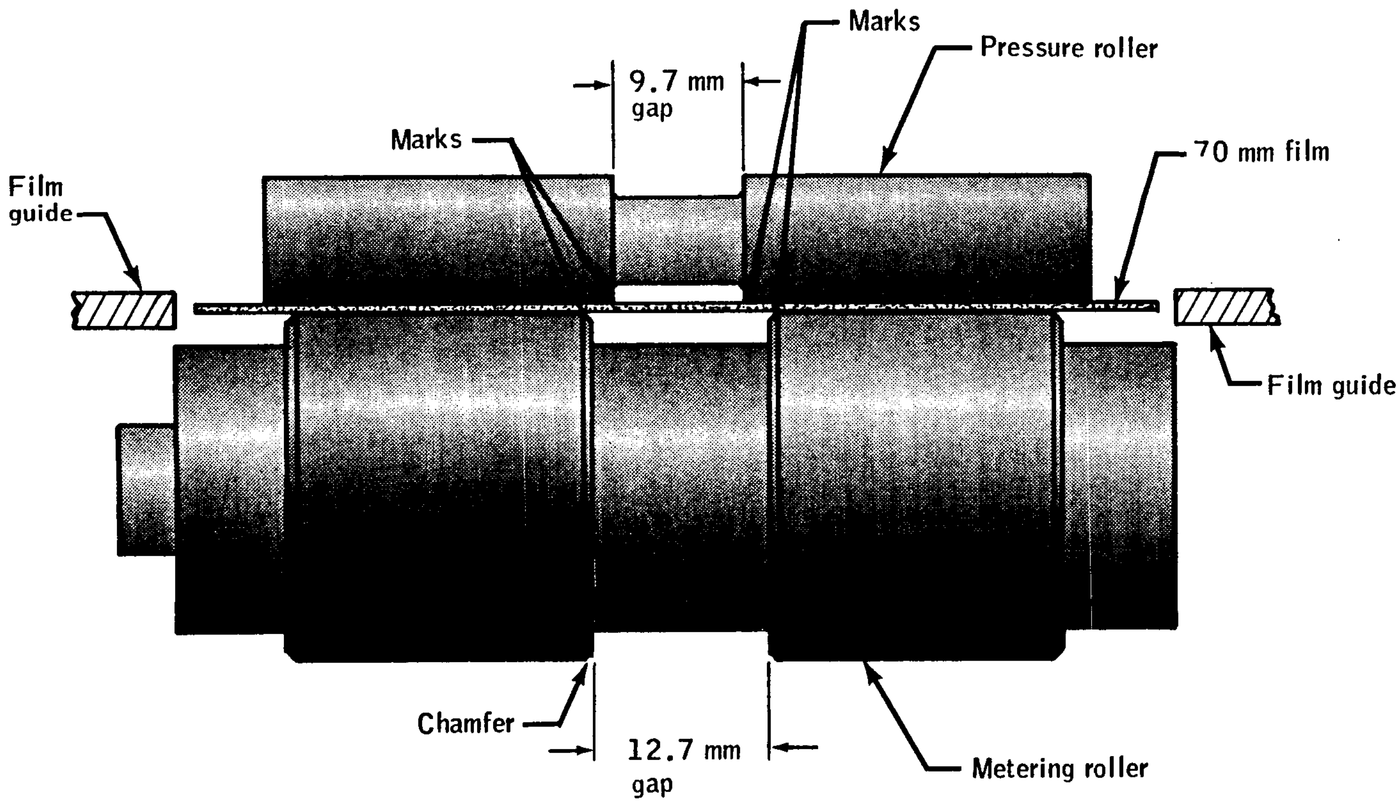


Figure 17.2-12.- Metering and pressure roller assembly showing the roller gaps correlating with the film marks.

The corrective action is to maintain the humidity level in the film vault by periodically recharging the moisturizing salt pads with water to keep the resupplied film at the proper moisture level.

This anomaly is closed.

17.2.7 Experiment S192 Multispectral Scanner Alignment Shift

The alignment of the scanner of experiment S192 is critical to the operation of the experiment. The scanner alignment apparently shifted as determined from the following conditions.

a. The alignment meter readings shifted when the crewman's hands were removed from the alignment controls during visible and thermal alignment.

b. The thermal alignment focus control was turned against the stop; which is not compatible with prelaunch mid-range settings for approximate alignment.

c. The thermal channel data show abrupt shifts in the value of a constant temperature target.

d. The visible and thermal channels have non-random noise superimposed on the data at frequencies of 8, 12 and 20 hertz. This is most pronounced on the thermal channel.

Figure 17.2-13 is an exploded view of the internal scanner assembly which shows the two radiation beams entering the internal scanner through the plate which adapts to the Multiple Docking Adapter. The visible light beam travels directly to the visible detector via the monochromator. The thermal infrared beam is folded to enter the dewar thermal window at a right angle to the visible beam.

Figure 17.2-14 shows the physical mounting arrangement of the two detectors with respect to their optical windows and also shows the shrink fit mechanism which conducts heat to the cooler.

Figure 17.2-15 shows the internal scanner assembly before the detector dewar assembly is in place in the optical bench cradle. The optical and thermal windows are visible in the detector assembly.

Figure 17.2-16 shows the detector dewar in place in its cradle. The large butterfly screws which tighten the upper half of the cradle are visible in this view. These screws were designed for finger tightening of

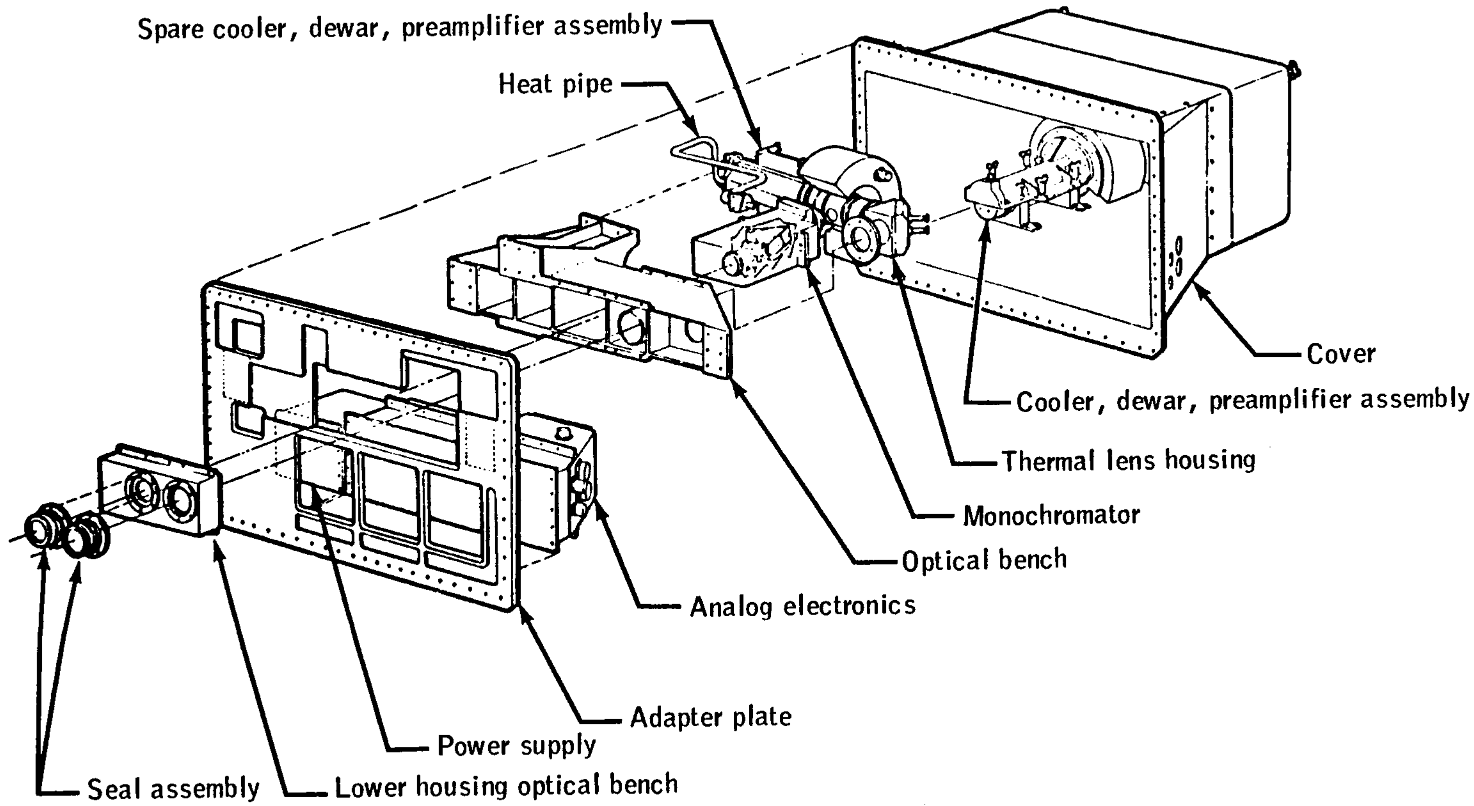


Figure 17.2-13.- Exploded view of internal scanner.

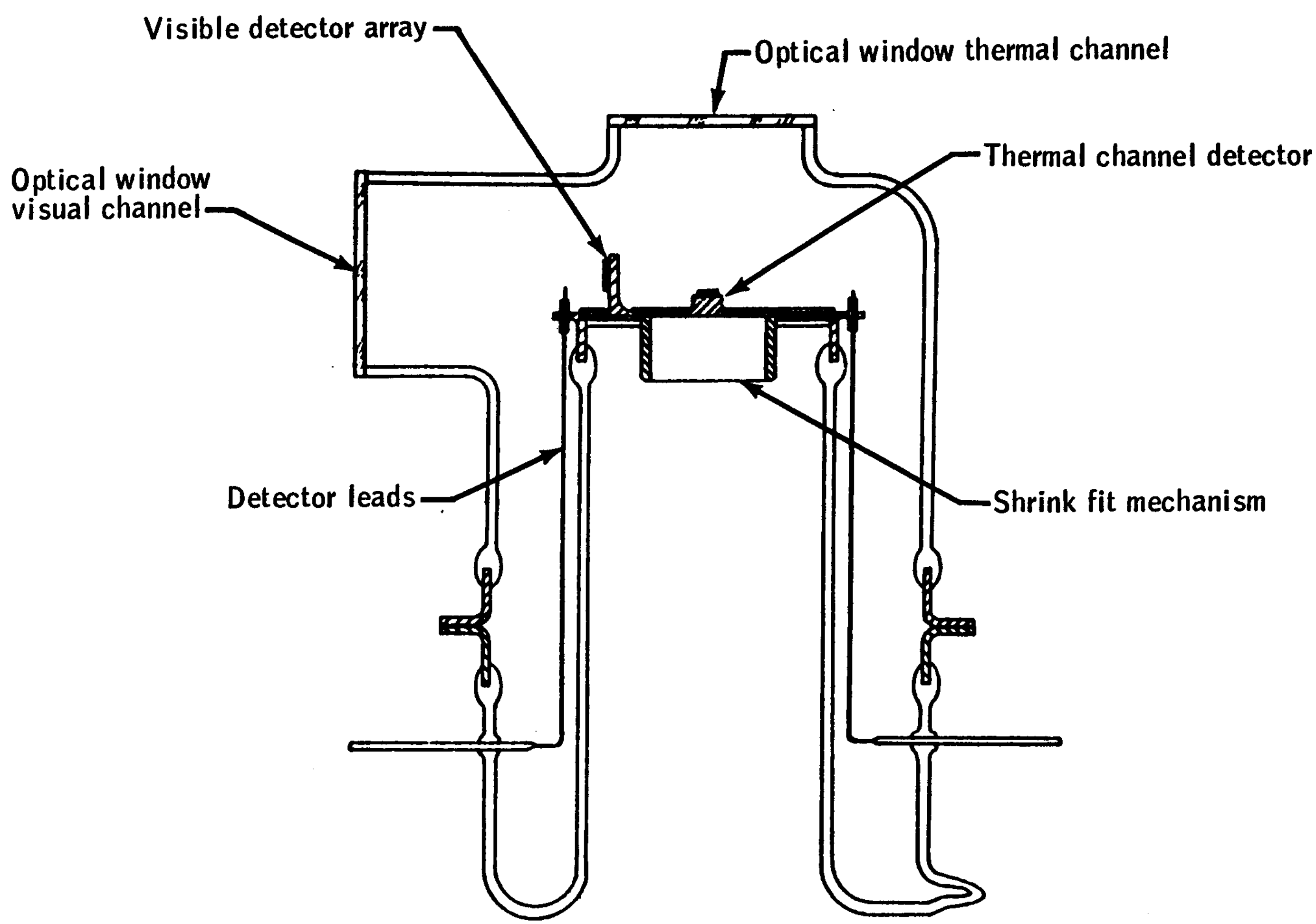


Figure 17.2-14.- Detector dewar.

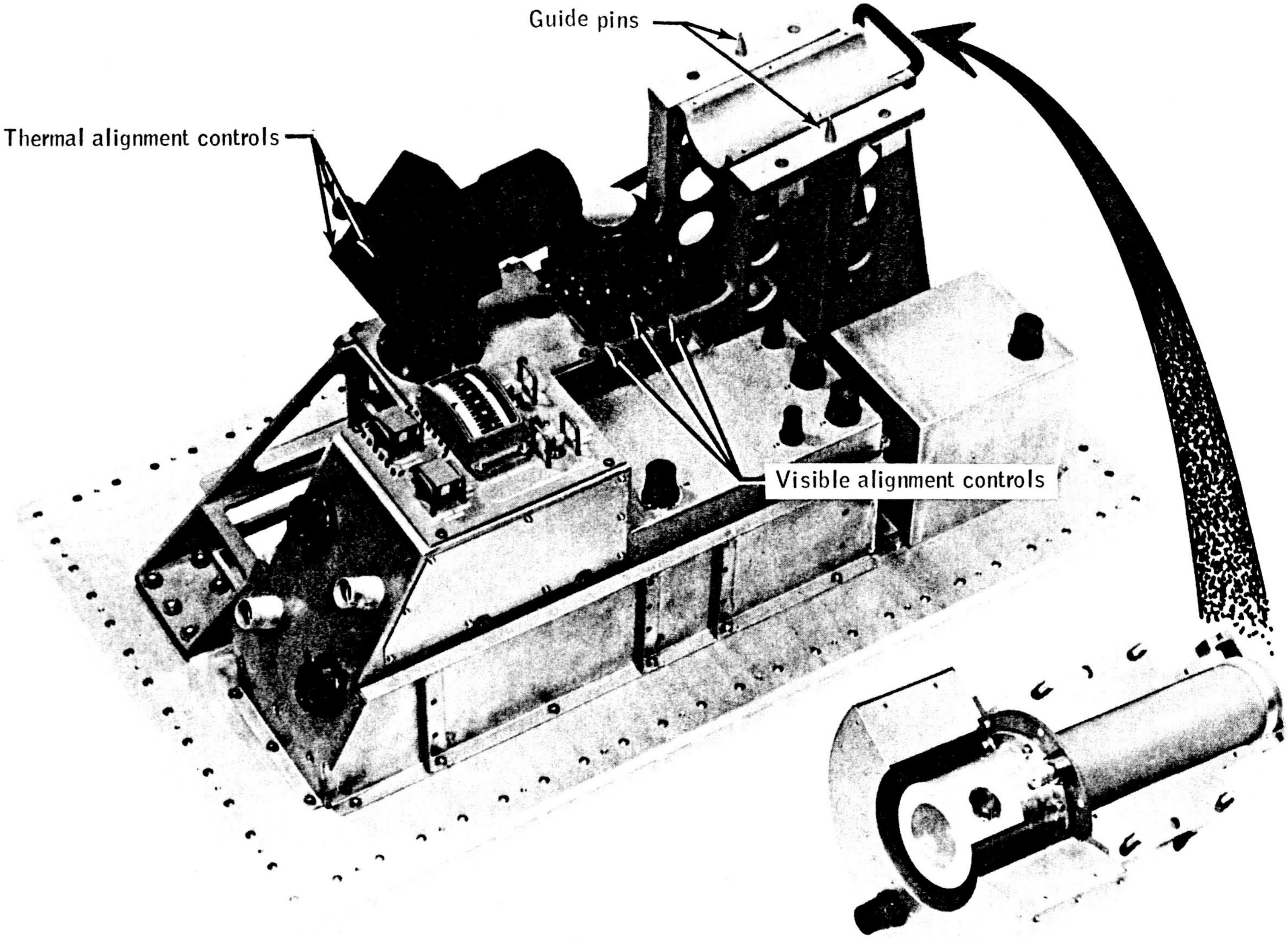


Figure 17.2-15.- Internal scanner and detector dewar assembly.

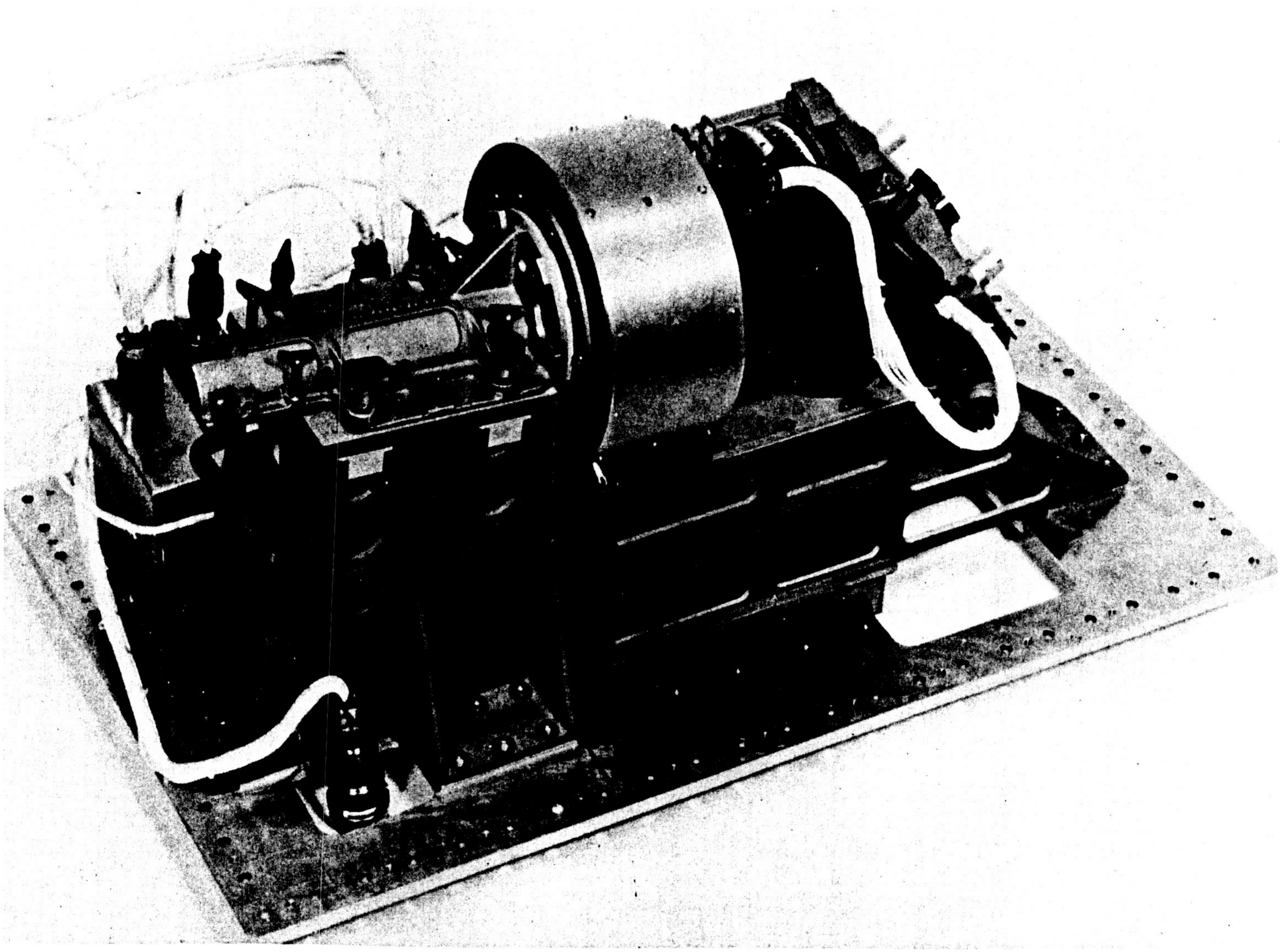


Figure 17.2-16.- Internal scanner with detector dewar in place.

the cradle about the cooler cylinder so that the primary detector dewar assembly could be replaced by the onboard spare in the event of a component failure.

When the detector assembly is lowered into place on the cradle, the guide pins (fig. 17.2-13) enter the holes of the upper flange insuring that the optical window is centered over the monochrometer lens when the assembly is seated fully. The large butterfly screws are then tightened to bring the upper and lower flanges together which brings the central axis of the thermal window in line with the folded thermal beam. The small butterfly screws are for tightening the heat pipe cradle to the cooler cylinder wall. There is an indium shim between the heat pipe cradle and the cooler cylinder wall to provide a tight fit and good thermal conductivity across the interface for a cooler heat sink.

The large butterfly screws are a differential type with two different thread pitches. The manner in which these screws tighten the cradle flanges to hold the cooler cylinder may be seen in figure 17.2-17. The nut is first captured blind by the screw coarse thread end. Further turning of the differential screw advances it into the upper flange and the nut. The advance into the nut, however, is more rapid than the advance into the flange (fig. 17.2-17). This permits a powerful clamping pressure to be exerted on the cooler cylinder without requiring tools.

The final alignment step of the detectors is accomplished with the fine alignment controls shown in figure 17.2-15. There are three controls for each detector, two for image location and one for focus. The internal scanner meter shown in figure 17.2-15 indicates the relative intensity of the alignment lamp beam spot on the detectors during the alignment mode. When the meter is peaked, alignment has been achieved.

The only factor which could account for all of the abnormal conditions is something loose in the internal scanner assembly.

There are three mating points which, if loose, could cause the observed conditions. They are the optical bench to the adapter plate for the Multiple Docking Adapter (fig. 17.2-15), the detector dewar assembly flange to optical bench brackets, and the dewar housing to circular bolt flange. The most probable loose point is the detector dewar assembly mating to optical bench brackets. The capture of the nut by the differential screws (fig. 17.2-15) can lead to an improper mating. Assuming the nut is not engaged in the first two turns of the screw, 2.5 centimeters of travel into the flange is lost because of the differential threads. This would permit the shoulder of the screw to contact the upper flange, giving a tight feel and leading to a false impression of tight mating of the flange. Improper engagement of the differential screws has occurred during ground testing.

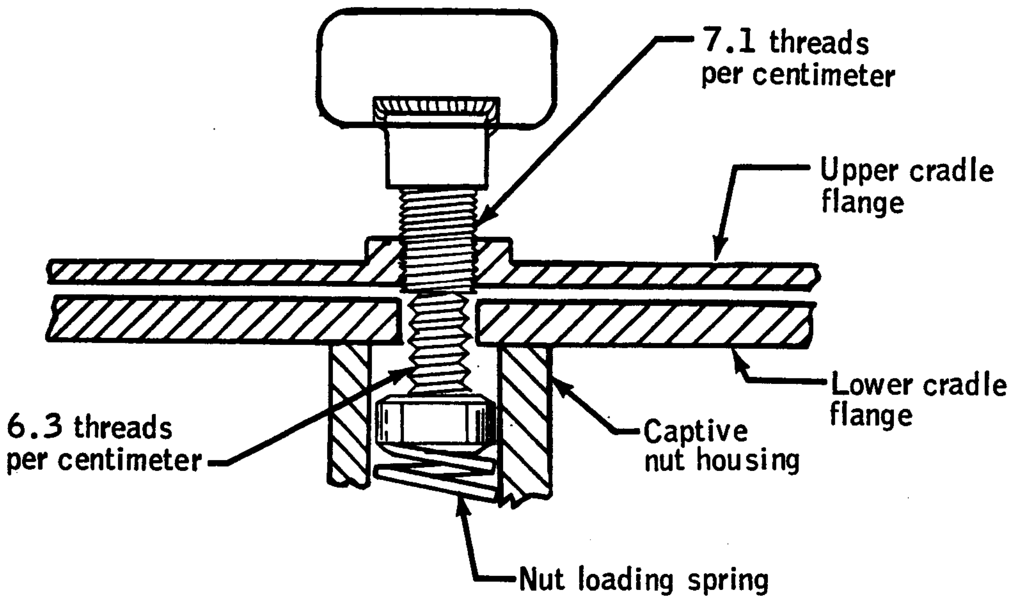


Figure 17.2-17.- Differential screw assembly.

In summary, the problems were caused by either the optical bench, the detector dewar assembly or the dewar being loose.

Crew procedures have been developed and the crew has been trained to identify the loose component and to tighten it during the next visit.

This anomaly is closed.

17.2.8 Experiment S193 Altimeter Pulse Compression

Experiment S193 (Microwave Radiometer/Scatterometer and Altimeter) failed in the pulse compression sub-mode of mode 5 during the Earth Resources Experiment Package passes.

The purpose of the S193 altimeter experiment is to gather data to allow comparison of pulsed radar type altimeter performance using various pulse widths, spacings and compression techniques. The affected portion of the altimeter experiment is used to compare altimeter operation using a 10 nanosecond pulse, a 130 nanosecond pulse compressed to 10 nanoseconds and a 100 nanosecond pulse. The 10, 100, and 130 nanosecond return pulse data of this mode has been recorded and are usable. The 130 nanosecond pulse was not compressed to 10 nanoseconds.

In mode 5 operation, a bi-phase modulated 130 nanosecond pulse of radio frequency energy is transmitted to the ground. The pulse is reflected back to the spacecraft antenna, and in the pulse compression sub-mode, is fed into a 130 nanosecond delay line. The delay line effectively shortens the 130 nanosecond return pulse to 10 nanoseconds and multiplies its amplitude by 13. The delay line is automatically switched into operation during the pulse compression sub-mode by use of a latching relay.

The data indicate that the transmitted pulse is being properly modulated, but the return pulse is not being compressed. This could occur only if the latching relay which supplies the return pulse to the delay line was not being operated.

The S193 experiment is mounted externally on the airlock, consequently no inflight repair or replacement is possible.

This anomaly is closed.

17.2.9 Experiment S193 Altimeter Data Frames Missing

During the double pulse operating mode of the altimeter, two data frames were not generated.

The altimeter experiment is designed to determine the optimum pulse width and shape, and optimum time between transmitted pulses for an altimeter operating in earth orbit.

In the double pulse mode of operation, each ranging transmission consists of two radio frequency pulses. A time delay, which is controlled by the measured altitude, starts when the first pulse is transmitted, and times out about 200 nanoseconds before the reflected pulse from the earth arrives at the antenna. The receiver noise level is measured once every 25 nanoseconds for four measurements; the first at 100 nanoseconds after the time delay times out.

The time between the first and second ranging transmissions is automatically varied in discrete steps so that the minimum time can be determined between ranging transmissions that will not result in interference between one ranging transmission and the next.

The information in the first missing data frame is the time between the end of the time delay time out and the first receiver noise measurement. The information contained in the second missing frame is the time between the first ranging pulse and the longest delayed second ranging pulse.

An altimeter calibration is performed before and after each altimeter ranging operation in the double pulse mode. The data which are missing during the ranging operation are also generated during each calibrate period; consequently, the missing data are not needed.

The same problem occurred during low temperature ground testing of the flight hardware, and was believed to have resulted from operation at temperatures below the lowest temperature that the equipment would experience in flight.

Since the same data are produced during altimeter calibration, experiment data analysis can be performed.

This anomaly is closed.

17.2.10 S193 Radiometer Automatic Gain Control Saturated

During radiometer operation of Experiment S193 (Microwave Radiometer/Scatterometer and Altimeter) the radiometer automatic gain control circuit was saturated (overdriven) for about the first 30 seconds of each radiometer operation that followed an altimeter operation. This resulted in a false indication of received signal strength.

During altimeter operation, the altimeter transmitter (fig. 17.2-18) supplies a high power pulse of radio frequency energy through a directional coupler (circulator D) to the experiment antenna. The pulse is then radiated to the earth and reflected back to the antenna. The reflected energy received by the antenna is then supplied back through circulator D to circulator E and then into the receiver input circuits. The time between the transmitted and received pulses is then proportional to the altitude of the antenna above the earth's surface.

During radiometer operation, energy radiated by the earth and received by the antenna is supplied through circulators D and E to the receiver input circuit and then to the radiometer receiver. To control the radiometer receiver gain, the direction of circulator E is periodically reversed, coupling the output of circulator F through circulator E to the receiver input. At this time, circulator F direction is commanded counterclockwise and the noise voltage from temperature reference (T_1) is supplied to the receiver. The voltage is demodulated and supplied through the receiver polarity control switch to an integrator (fig. 17.2-18). At this point, the polarity control switch is in the positive position and the receiver positive output is integrated for a fixed time period. Circulator F direction is then commanded clockwise and temperature reference (T_2) noise voltage is coupled to the receiver. Also, the polarity control switch is commanded to the negative position and the integration continues for an additional time period equal to the original positive integration period. The integrator output voltage at the end of the two integration periods is then proportional to the temperature difference between the two reference temperature sources. This voltage is compared to a fixed reference voltage and an automatic gain control voltage is developed. This voltage is used to control a variable attenuator on the receiver front end, controlling receiver end to end gain.

During altimeter operation, the radiometer was left in standby. In this condition, the radiometer automatic gain control circuit operated and attempted to control radiometer receiver gain. However, since each circulator supplies only 30 dB of attenuation between the input port and the port which is uncoupled from the input port, enough transmitter energy was coupled through circulators D and E to the receiver input to cause the automatic gain control to saturate. When the altimeter was turned off and the radiometer was switched to operate, the automatic gain con-

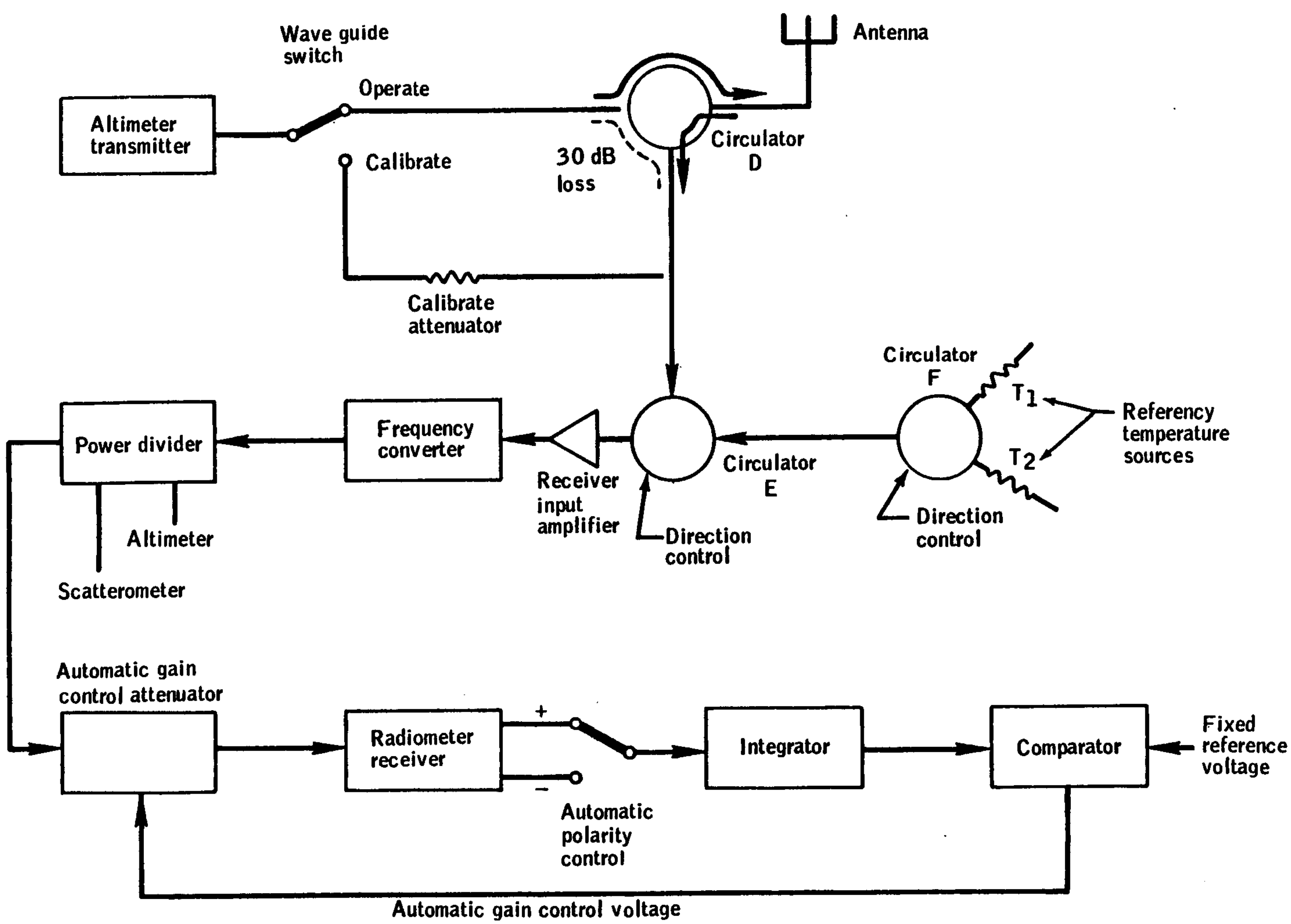


Figure 17.2-18.- Radiometer automatic gain control circuits.

trol circuit, because of its long time constant, took about 30 seconds to come out of saturation and the first 30 seconds of radiometer data were lost (radiometer operate periods are normally about 1 to 5 seconds long). This operation was duplicated with the backup flight hardware.

The radiometer automatic gain control circuit is disabled when the radiometer is turned off. Therefore, for future experiment operations, the radiometer will be turned off before the altimeter is operated. When radiometer operation is performed following altimeter operation, the altimeter will first be placed in standby and the radiometer will be switched from off to standby, then to operate.

This anomaly is closed.

17.2.11 Experiment M133 Recorded Data Noisy and Unusable

The electroencephlogram, electroculogram, and head motion data were recorded while a crewman was asleep. The recorded tape was returned and played back. Of the 100 hours of data recorded, the first 16 hours was usable and of high quality. All subsequent recorded data were so noisy that the data could not be recovered.

The first visit was launched with two experiment M133 recorders on board, each containing a reel of tape. A third reel of tape was stowed in one of the sleep compartment lockers. During the high temperature period prior to the first visit manning, the tape reel stored in the sleep compartment locker reached about 332° K. Consequently, a special thermal test of a reel of tape was performed using the flight temperature profile. The tape was then recorded and played back. In that case, the first 12 minutes of played back data were good, and thereafter, the played back data were noisy and unrecoverable.

The noise characteristics of the returned tape are similar to the tape subjected to the ground temperature testing discussed previously. Two reels of tape were resupplied for the second visit.

Further investigation of the cause of this condition is continuing.

This anomaly is open.

17.3 GOVERNMENT FURNISHED EQUIPMENT ANOMALIES

17.3.1 Blown Fuses in 70 mm Camera During Film Transport

The crew reported two blown fuses in the 70 mm camera when using magazine CX-04.

The 70 mm camera magazines are loaded for flight with a full supply spool of film and an empty take up spool. The drive gear train and associated indicators (fig. 17.3-1) for the spools are all contained in a thin compartment on one side of the magazine. The film path through the main magazine compartment is superimposed in a dashed line to show the relationship with the manual film advance lug and shaft. The camera drive interface gear engages the motor driven gear on the camera when the magazine is mated with the camera. All film transport and indicator motions are derived from this gear.

The drive enable pawl (fig. 17.3-1) swings both left and right about the pawl pivot point. When the pawl is pivoted to the left position, a flat metal switch arm enters the magazine. This switch arm enables the camera motor to drive the gear train through a film transport cycle, transporting an unexposed frame of film in front of the platen whenever the camera operate button is depressed. When the film transport is synchronized (no overlap or skip), the red/white flag will show white through a small circular window in the gear train cover. When the pawl is pivoted to the right position, the camera switch arm is prevented from entering the magazine and the motor cannot be started. Simultaneously, the red indicator will show under the window, indicating that the film transport is not synchronized. The film may then be manually advanced by turning the manual film advance lug which extends through the gear train cover. The manual advance is continued until the white indicator appears in the window, at which time the film is re-synchronized. Depressing the camera operate button will restore normal exposure and advance, if the camera fuse is not blown.

Two possible causes existed for failure of the camera to operate. One is that the film is out of synchronization. The other is a blown fuse. The fuse protects the camera motor in case of a hard jam of the gear train or film.

Postflight inspection of the magazine revealed a red indicator under the window, showing that the film advance was out of synchronization at the time the magazine was removed from the camera. This evidence is not conclusive in selecting which of the two causes of failure is responsible, because a fuse can be blown in the middle of a cycle. This magazine was

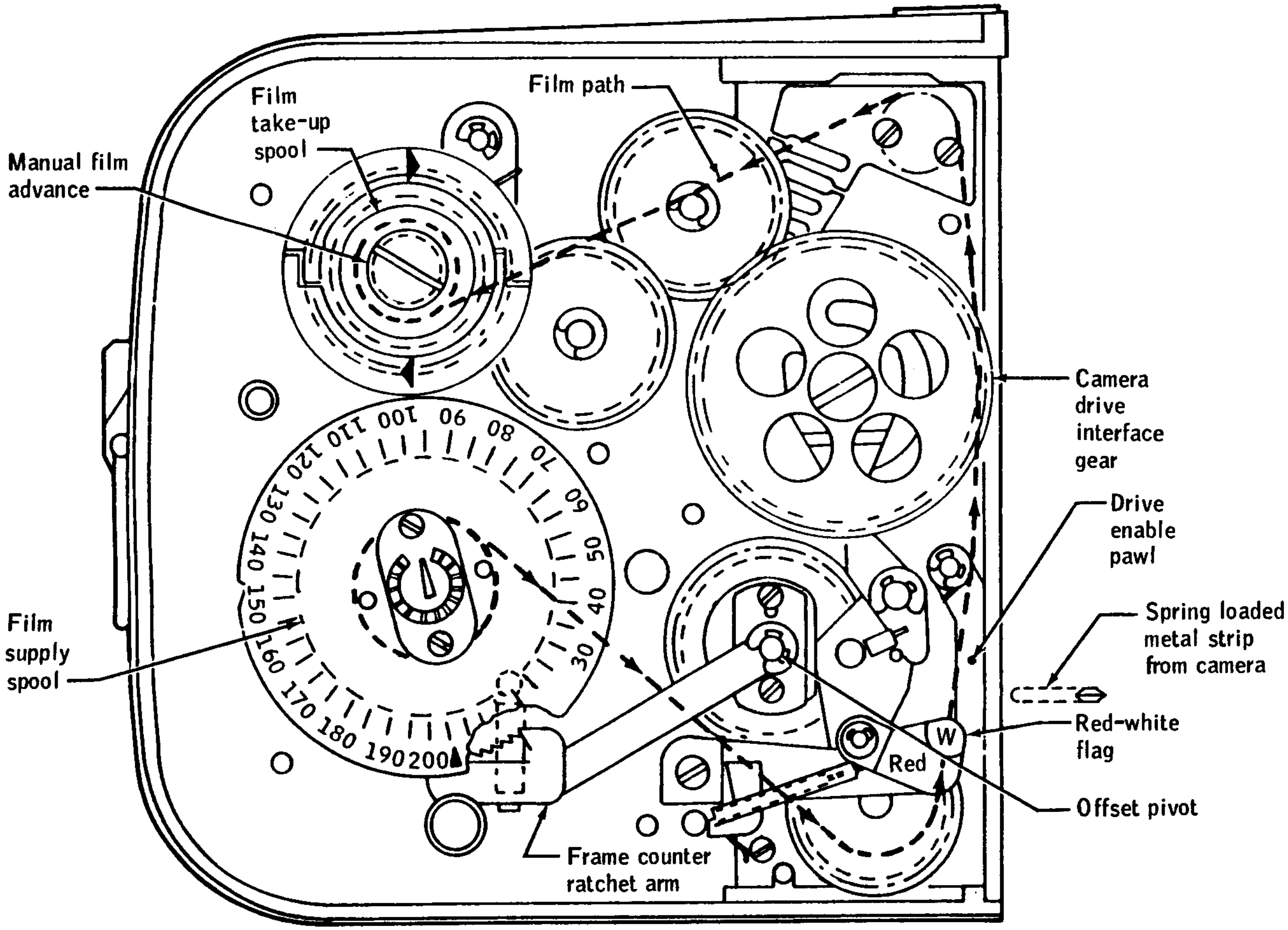


Figure 17.3-1.- Magazine for 70 mm camera.

mated with the flight camera, manually advanced to a white flag and then cycled to film depletion with no further anomalies.

The flight camera stopped in the middle of a cycle and a red flag was noted during an inflight frame advance. The magazine was removed from the camera and the operate button was depressed with no response, indicating a blown fuse. The fuse was replaced, the magazine remated, and the film was manually advanced until the white flag was present. At this point, normal camera operation was restored. The camera was used for several more frames when the camera again stopped. The crew replaced both the magazine and fuse to insure proper operation of the camera.

Development of the film showed that the first stoppage was at frame 62. This is evidenced by a white over exposure. Following this, ten good pictures were noted and at frame 72, the second stoppage occurred.

A search, using magnification, of the gear compartment was made for debris which could possibly have caused jamming and the attendant fuse blowing, but no debris was found.

The developed film was inspected for evidence of emulsion sticking, tears, and other physical deterioration which might have caused jamming. No evidence of any of these conditions existed.

Film evidence and crew statements lead to the conclusion that the first stoppage was due to a blown fuse. It is also probable that the second stoppage also was due to a blown fuse. Four extra fuses will be carried up on the next visit.

This anomaly is closed.

17.3.2 70 mm Camera Frame Counter Failed

The 70 mm film magazines are loaded for flight with a full supply spool of film and an empty take up spool. The drive gear train and associated indicators for the spools (fig. 17.3-1) are all contained in a thin compartment on one side of the magazine. The film path through the main magazine compartment is superimposed to show the relationship with the manual advance and the frame counter wheel. The camera drive interface-gear engages the drive on the 70 mm camera when the magazine is placed in the camera. All other camera and film operations are taken off this main gear.

The frame counter ratchet arm (fig. 17.3-1) is spring loaded against the frame counter ratchet wheel and increments the wheel to bring the inscribed frame number under a window in the side cover of the magazine. The motion of this arm is obtained from an offset pivot point on the drive gear.

The crew continued to take photographs with this magazine when the counter stopped counting. The camera drive motor is automatically inhibited when the end of the film passes by the drive enable pawl, indicating the film had been used.

A postflight inspection showed that the frame counter ratchet wheel teeth were low in profile and rounded in the gear sector between inscribed frame numbers 60 and 72. Therefore, the frame counter ratchet arm claw could not engage the ratchet gear teeth in that sector. The inspection showed that the black anodize coating in the sector was intact and unabraded, confirming that the teeth were in the manufactured condition. Since the ratchet gear does not drive any other camera mechanism, all other camera and magazine functions were normal.

A full spool of dummy film will be cycled through each magazine before the flight film is loaded to verify this gear condition does not exist in other magazines.

This anomaly is closed.

17.3.3 Television Camera Failed

The crew reported that portable television camera (serial number 3005) had failed at 20:03 G.m.t. on visit day 9. The camera had been running and showing a good picture on the monitor, but abruptly ceased operating as the camera was being moved. The zoom lens was removed and the color wheel was not turning. About 25 hours earlier, the camera had been accidentally kicked which caused a collision with and rebound from the wall of the Orbital Workshop forward compartment.

The television color wheel drive train motor (fig. 17.3-2) is kept in proper video phasing by the color wheel synchronizer circuitry. This circuitry is triggered and synchronized by timing signals received from the synchronous generator. The synchronous generator also provides triggering and timing signals to the sweep and focus circuitry that generates the horizontal sweep, vertical sweep, blanking, and magnetic focus signals for the tube assembly yoke.

Postflight testing verified the failure was in the multichip hybrid synchronous generator package. No synchronizing signals were being generated, thus depriving the entire camera of triggering and timing signals. Without timing, there is no color wheel drive phasing signal, the tube assembly deflection coil sweep is not properly generated, and the video processing circuitry will not function.

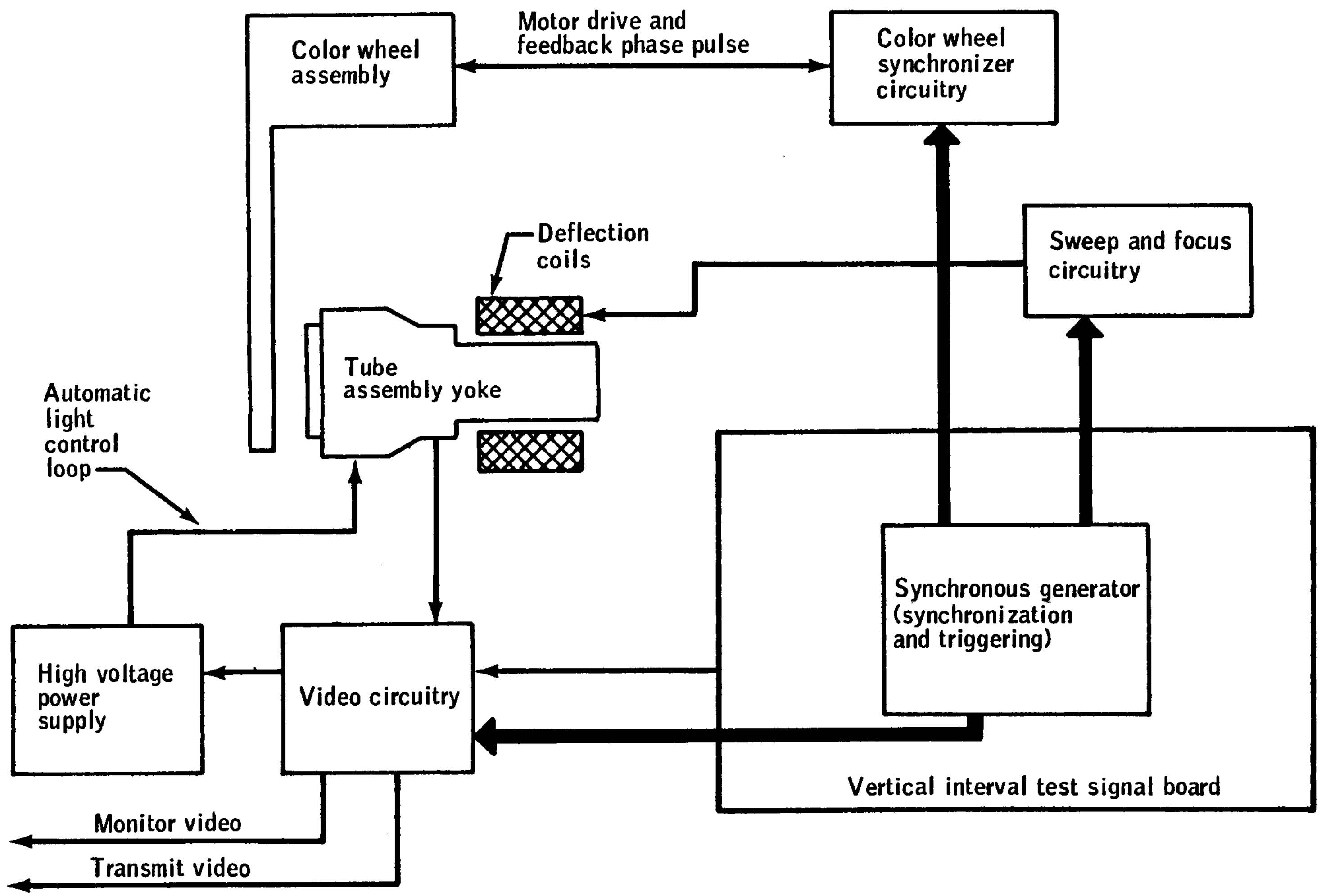


Figure 17.3-2.- Simplified color television camera loop synchronization and triggering.

The generator multichip hybrid package was operative however, after removal from the camera, and also after re-installation in the camera. The package was again removed and vibration tested, during which sensitive microphones detected the sounds of loose internal particles.

The package was opened and particulate contamination was found on the substrate and logic chips. The individual chips were insulated by a glass coating, but the interchip conductors were exposed and are subject to shorting by conductive contamination.

Tests showed the contamination was mostly tin and silver with minute traces of copper and gold. The tin and silver are solder constituents. The gold trace probably flaked off the substrate and the copper trace is foreign to the package. (The package had been opened two times prior to flight for repairs.) Since the package now operates, and the particulate contamination has been disturbed, it is not known which sub-circuit was shorted.

Postflight testing of the synchronous generator, while it was still inoperative, combined with analysis, shows that all 21 chips were probably deprived of the 5 volt dc power. The 5 volt dc power conductor strip is relatively long as it leads to every chip and the shorting probability is greater than for other elements. The package itself is quite small (fig. 17.3-3) and very small sized contamination could easily bridge two conductors and short out a part of, or the entire package.

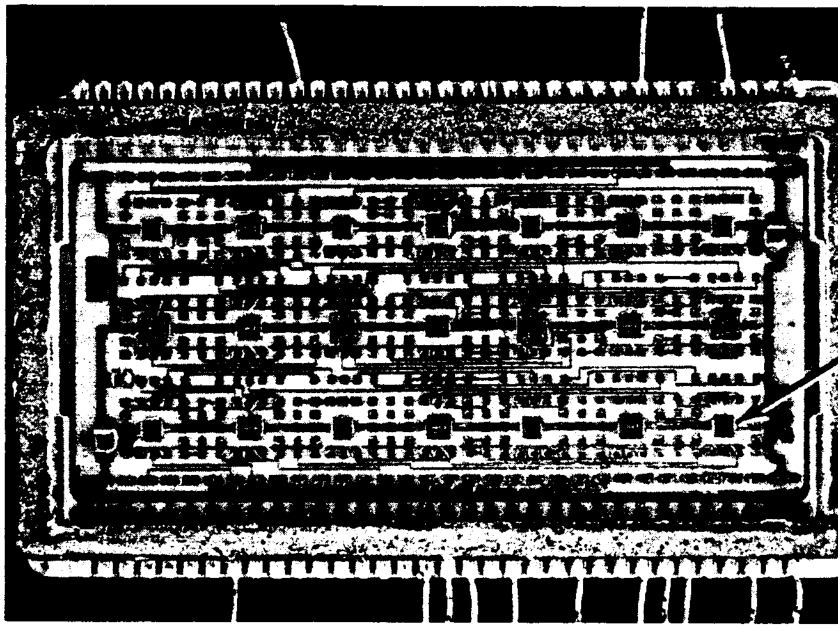
The shocks received by the camera during flight probably dislodged the contamination, allowing it to move within the package, and about a day later, one or more particles shorted out the entire synchronous generator within the package.

The television camera failure was probably caused by tin/silver solder particles within the synchronous generator multichip hybrid package that were introduced during the two repair operations prior to flight. Furthermore, not all of the camera multichip hybrid packages were screened on the acoustic vibrator for contamination.

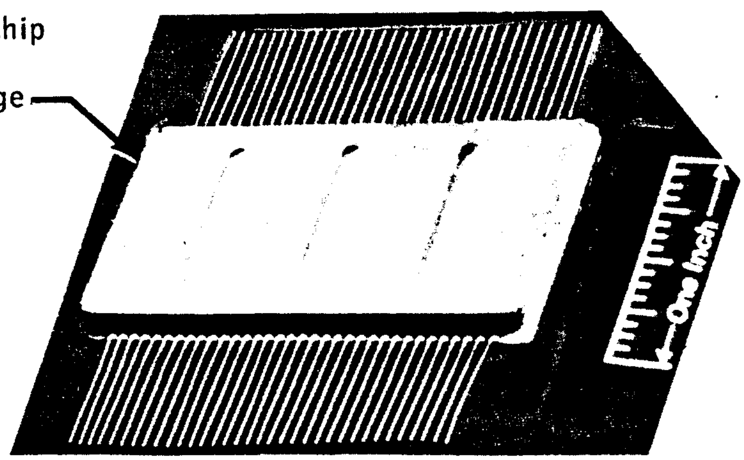
The two television cameras to be flown on the second visit will not have their multichip hybrid packages removed for testing for contamination. Such action would require extensive disassembly of the cameras. Each camera contains twelve packages and the disassembly would most likely result in lowering the camera reliability. Further this was the first such operational failure.

In case the problem recurs during the next visit, a backup camera is available.

This anomaly is closed.



(a) Contaminated synchronous generator with lid removed.



(b) Synchronous generator with lid intact.

Figure 17.3-3.- Synchronous generator.

17.3.4 Spotted Images Observed on Television Ground Monitors

Spots were observed on the television images viewed through the experiment S191 viewfinder tracking system telescope. The spot patterns varied on other transmissions. For ordinary transmissions, a zoom lens is used with the camera (fig. 17.3-4).

A television optical adapter is used for transmissions of viewfinder tracking system images with the camera at the data acquisition camera port (fig. 17.3-5). The viewfinder tracking system telescope (fig. 17.3-6) is used to locate and track ground targets. The viewfinder tracking system zoom lens provide a 10 to 1 variation in magnification. Apparent image rotation is corrected by the collimation and decollimation lenses, the image rotation prism, and the erecting prism. The reticle provides a reference for accurate pointing.

The telescope dichroic element (beam splitter) reflects a portion of the radiation into the data acquisition camera optical system and transmits the remainder to the eyepiece. The dichroic element also superimposes the numerical display on the field of view. Either the data acquisition camera, or the television optical adapter and camera, are mounted on the telescope during experiment operations.

Two types of spots were observed. The first spots were observed when the television camera was used with the optical adapter on the viewfinder tracking system during Earth Resources Experiment Package passes 9 and 10. The images had a pattern of an increasing number of blurred and sharply focused spots, mostly fixed with respect to the reticle.

The second group of spots were observed when the television camera was used with the zoom lens; the spots were blurry and in a fixed pattern that did not change in number or location.

Investigation of the flight camera disclosed particulate contamination on the forward surface of the tube assembly faceplate. Because the focus plane is near the back surface of the face plate, the spots produced on the transmitted images were blurred. The two contaminated surfaces face each other as shown on figure 17.3-4. The contamination may be black anodizing material that may have flaked off the filter wheel gear teeth. Efforts to identify the contaminate are continuing.

The inspection of the viewfinder tracking system by the crew did not disclose any spots through the eyepiece, nor was any contamination noted in the data acquisition camera photographs. An assessment of the contribution of the viewfinder tracking system telescope to the contamination

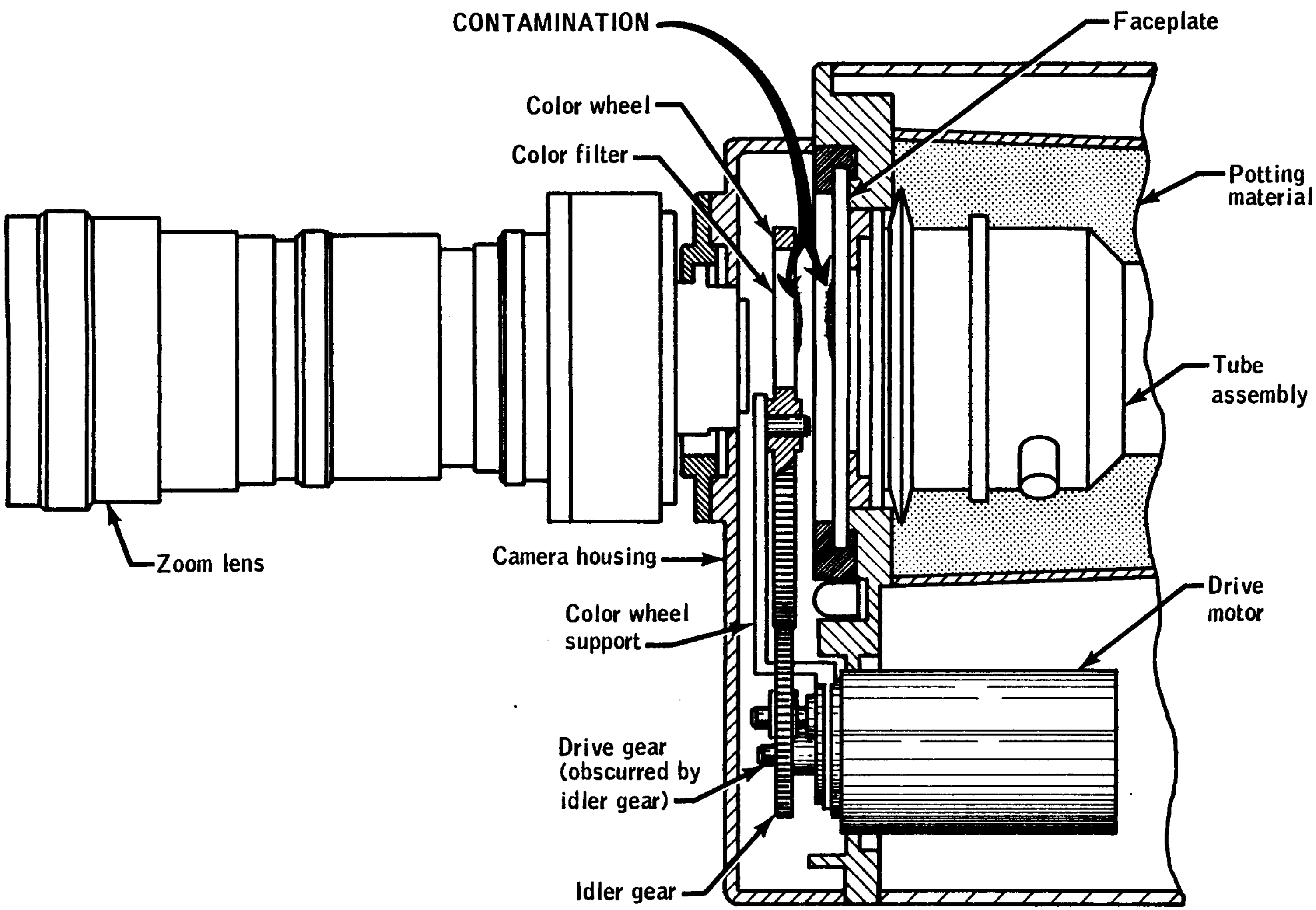


Figure 17.3-4.- Contamination location within television camera.

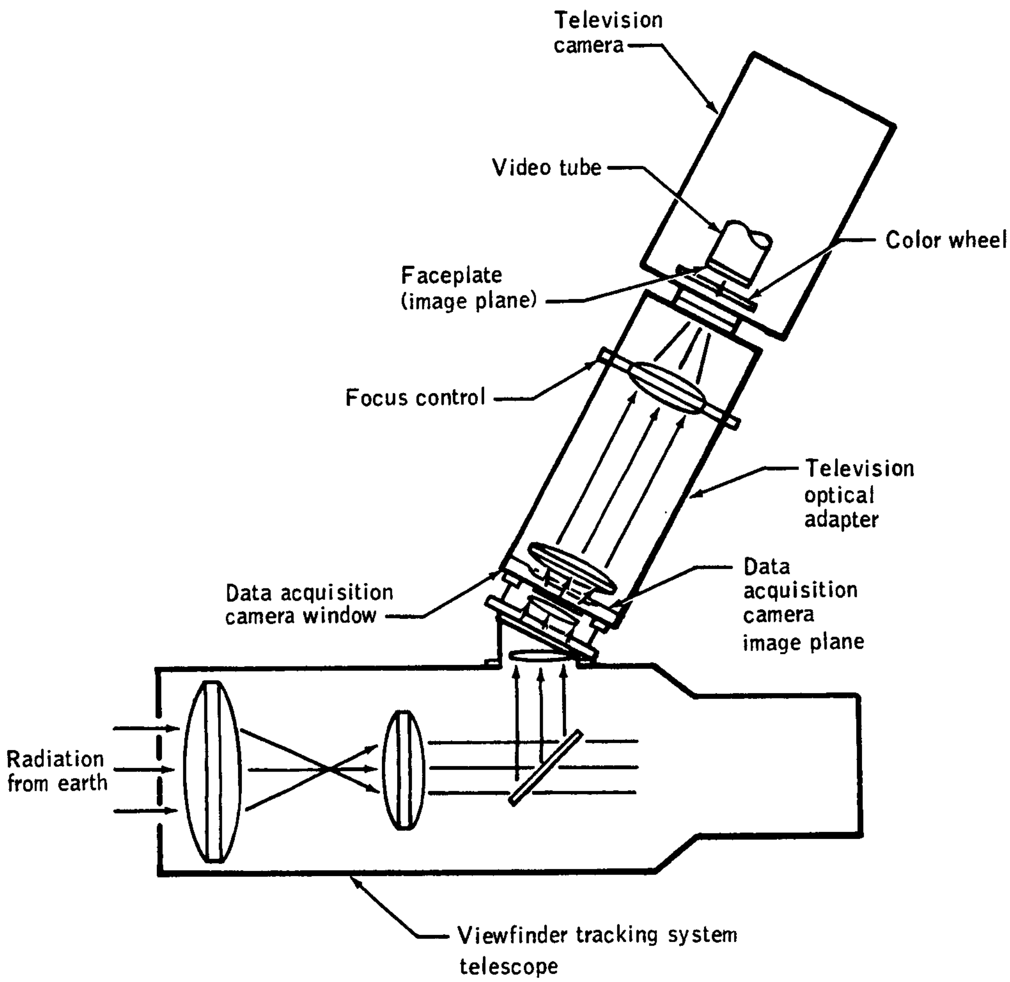


Figure 17.3-5.- Television camera configuration used with viewfinder tracking system telescope.

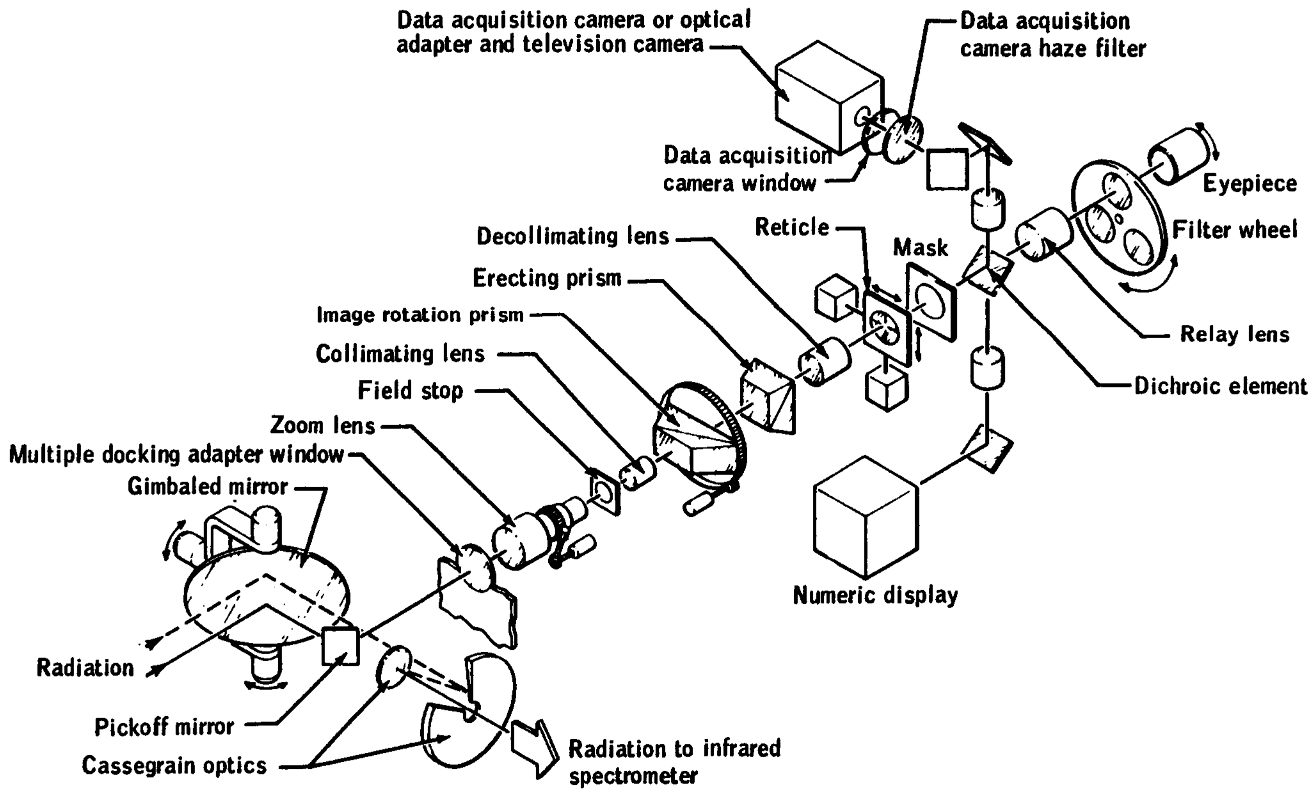


Figure 17.3-6.- Experiment S191 viewfinder tracking system optical diagram.

shows that the entire telescope optical loop is probably free of contamination. However, the crew did remove contamination on the outside optical surfaces (data acquisition camera window and optical adapter outer lenses). Therefore, the sharply focused spots were caused by the particles the crew removed from the external surfaces, and the telescope internal elements are clean. The blurred spots observed on the television images were caused by the particles on the faceplate.

The faceplate, color wheel, and drive train were cleaned and inspected on the two television cameras to be used on the second visit.

The degradation of picture quality is not significant and therefore, does not warrant color wheel redesign. If, after extended use, the number of spots on the transmitted images becomes significant, the spare camera can be used or the faceplate can be cleaned by the crew.

This anomaly is closed.

17.3.5 Carbon Dioxide Meter/Dew point Monitor Failed

Early in the visit, a white residue was found around carbon dioxide sensor A of the portable carbon dioxide/dew point monitor. Measurements taken at that time disagreed with other onboard instrumentation in that sensor A indicated 160 newtons per square meter, sensor B indicated 1600 newtons per square meter, and the onboard reading was 640 newtons per square meter.

Seven days later, the crew used the carbon dioxide/dew point monitor to measure dew point. The measured value was 297° K and, at the same time, the onboard instrumentation was recording approximately 283° K, indicating that the dew point measuring portion of the unit had failed.

The portable carbon dioxide/dew point monitor permits measurements of carbon dioxide partial pressure in a range of 1.3 to 4000 newtons per square meter, and dew point and ambient gas temperatures in ranges from 278° to 311° K at any place within the Saturn Workshop.

The carbon dioxide monitoring system (fig. 17.3-7) consists of two electrochemical sensors and associated amplifiers. The solid state amplifiers drive a readout meter on the front panel of the monitor.

Each carbon dioxide sensor is a small electrochemical cell consisting of a pH sensitive glass electrode, a reference electrode, an electrolyte gel, and a thin membrane. Both electrodes are enclosed within a single housing and bridged by the electrolyte. The membrane is stretched

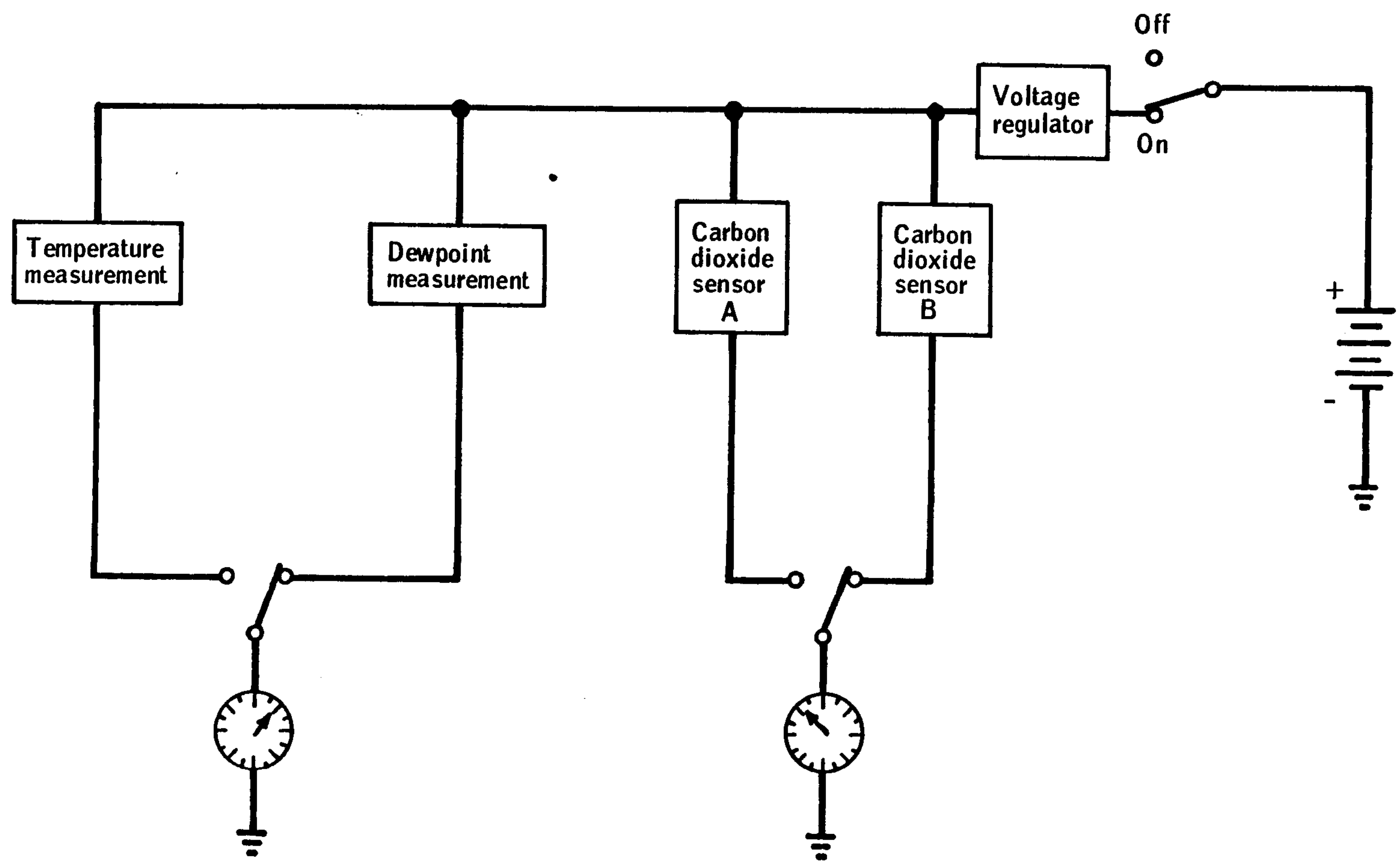


Figure 17.3-7.- Portable carbon dioxide/dewpoint sensor.

across the sensor portion of the glass pH electrode. The membrane is permeable to carbon dioxide while keeping airborne solid or liquid contaminants away from the gel. The electrolyte pH changes with exposure to carbon dioxide. Electrode potential is proportional to the logarithm of the partial pressure of carbon dioxide in the air sample.

The dew point ambient temperature sensor contains a mirror surface which is bonded to a small thermoelectric cooling module.

The module pumps heat from the mirror and lowers the temperature of the mirror surface. As the mirror temperature reaches the dew point, the mirror surface fogs. The mirror surface reflects light to a photoelectric sensor which operates in a bridge. The bridge output is amplified and used as feedback to control the cooler. The servo loop stabilizes the mirror temperature at the dew point (mirror surface just fogged). The mirror temperature is then measured and displayed by the panel meter as the dew point temperature.

A hand operated air sampling pump is located at the top of the carbon dioxide/dew point monitor. The pump draws air through the inlet into the air sampling compartment, where the air contacts the dew point ambient temperature sensor and both of the carbon dioxide sensors.

The carbon dioxide partial pressure readings taken on visit day 8 indicate that both carbon dioxide sensors were failed. The white residue noted around sensor A was most probably dried electrolyte that had been pulled through the membrane by exposure to pressures below the instrument design limit of 0.34 newtons per square centimeter. Development testing with these sensors demonstrated that electrolyte can be drawn through the membrane by exposure to pressures of approximately 0.17 newtons per square centimeter as were experienced on the Orbital Workshop during postlaunch venting to purge potential toxic gases. This depletion of electrolyte would cause a low carbon dioxide reading. The cause of the failure of carbon dioxide sensor B is unknown.

The dew point measurement on visit day 8, indicated that the dew point sensor was working at that time. However, the measurement which was made 7 days later indicated the dew point sensor was not working properly. Possible causes of this failure are an inoperative cooler, an inoperative light bulb, or failure of the dew point ambient temperature meter switch.

This portable unit was planned for use only during the first visit to measure carbon dioxide dew point and temperature in various workshop locations. Fixed sensors will be used during the second and third visits; therefore, no action will be taken.

This anomaly is closed.

17.3.6 Van Allen Belt Dosimeter Data Exhibited Periodic Spurious Excursions

The Van Allen Belt dosimeter telemetry data showed spurious alternations superimposed on the good data every 20 seconds starting on visit day 21 between 16:40 and 17:50 G.m.t. These excursions were observed when the readings were near zero, as well as when the readings rose as high as 0.9 Rad/hr.

Each data excursion lasted about 10 seconds and consisted of a negative variation followed by a positive variation. The variation peaks ranged from 4 to 7 percent of full scale. Each excursion was followed by 10 seconds of good data resulting in 50 percent usable data.

The Van Allen Belt dosimeter measures the radiation dose in radiation absorbed dose per hour (Rad/hr) in the Orbital Workshop on the bulkhead between the wardroom and the waste management compartment. The dosimeter consists of two ion chambers and the associated electronics that measure skin dose and depth dose. The skin dose is equivalent to the radiation impinging directly upon a crewman's skin. The depth dose is equivalent to the radiation penetrating beneath 5 centimeters of skin tissue depth, and provides information on dose rates that penetrate into the blood-forming regions of the body.

The Van Allen Belt dosimeter was changed on visit day 26 at about 17:00 G.m.t. The telemetry received from the second unit also exhibited the same excursions.

At the time of the problem, the command module inertial measurement unit heater was being powered by both main buses. The heater uses about 3 amperes, which is split between Airlock Module power bus 1 and 2. The dosimeter is powered by Airlock Module power bus 2. The heater was switching on for 5 seconds every 20 seconds as determined by telemetry of the current traces on the Airlock Module transfer busses. The heater current rise and fall times are very short and, therefore, introduce a sharp inductive pulse to the other loads on the line.

The dosimeter data excursions correspond exactly in time with the heater cycles. The heater cycling introduced noise on the bus which could not be filtered.

The inertial measurement unit was not operated with the heaters cycling prior to flight.

The data are readable and valid between the heater cycles. No corrective action is required.

This anomaly is closed.

17.3.7 Erratic Operation of 35 mm Camera Incrementing Frame Counter

The 35 mm camera incrementing frame counter occasionally missed frame counts. The frame counter resets each time the camera back is opened. When the film is loaded, and the camera back is closed, the film is manually advanced to the point where the number 1 shows on the counter. Each time the film is advanced one frame, the counter increments by one count, and in this manner the counter indicates the number of frames used.

When the camera back is closed after loading the film, a tab on the camera back cover depresses the counter engage lever on the camera. This depression pushes a linkage assembly which engages the teeth on the counter mechanism so that the counter is incremented one count for each frame advance.

The most likely cause of the lost counts was an insufficient depression of the counter engage lever. As a result, the linkage did not fully engage, which allowed random skipping of the frame counts.

The camera also has a decrementing counter which is manually set to the maximum number of frames in the loaded film roll. The counter is directly driven by film spool movement.

A procedural change was implemented during the first visit to use only the decrementing counter which provides an accurate indication of film usage.

The camera was not returned and no crew repair will be attempted as this problem has no effect on the mission.

This anomaly is closed.

18.0 CONCLUSIONS

The following conclusions are drawn from the information contained in this report.

1. Resolution of the seemingly insurmountable system difficulties that occurred on this flight demonstrates the advantage of having man onboard space vehicles.

2. This flight demonstrated that for long term manned and unmanned space flight, provisions should be made for unforeseen inflight repair and maintenance in the form of accessibility, hand holds, tools, facilities, materials, and hardware appropriate for interior and exterior operation.

3. There were no operationally significant physical or psychological health problems associated with the space vehicle environment for the 28 day visit, and there were no findings that would preclude longer duration visits.

4. The habitability provisions were satisfactory and contributed to the ability of the crew to work effectively for a visit of this duration and no factors were identified to preclude longer duration visits.

5. Operation of the command and service module systems in a semi-quiescent state was demonstrated for the 28 day period, and no factors were identified which preclude operation for longer periods.

6. Extensive scientific data were returned in all planned experiment disciplines.

7. The methods and techniques employed in the daily flight planning provided the flexibility to react to major departures from preflight plans and constraints. This ability was an important factor in optimizing the scientific return.

8. The various experiment groups were organized effectively within each discipline and functioned well as a unit. In addition, with the excellent cooperation between the various experiment groups, flight planning techniques were effective in resolving interdisciplinary conflicts and integrating the diverse experiments program.

9. Long duration flight with sophisticated multi-discipline experiments generate large amounts of data requiring ground data handling and processing capabilities.

10. Overall objectives of the visit were accomplished.

APPENDIX A - CAMERA SYSTEMS AND EQUIPMENT DESCRIPTION

This appendix contains a description of the camera systems used on the first visit.

A.1 16 mm Data Acquisition Camera

Figures A-1 and A-2 show the items which comprise the 16 mm data acquisition camera system for use on the Skylab program. The principal component is the 16 mm camera which uses 28 volts dc for power and provides sequence operation in lieu of cine operation. Shutter speeds range from 1/60 to 1/1000 second and frame rates are time exposure, 1 or 2 frames per second, 6 frames per second, 12 frames per second, or 24 frames per second. Camera film is provided in a 43 meter magazine and a 122 meter canister. The 122 meter canister is part of a unique three part 122 meter magazine system. The camera system also included various lenses, brackets, power packs, and tools. The quantities of each item are identified in Table A-1. The various photographic tasks necessitated many types of film. The types and amounts of film for the first visit are as follows:

Film type	Amount, meters
SO-368	137
SO-168	3170
130AOUV	61
2485	91
3401	91

A.2 35 mm Camera System

The 35 mm camera system for the first visit consisted of a 35 mm camera body (fig. A-3), 55 mm f/1.2 lens, 35 mm f/1.4 lens, 300 mm f/4.5 lens, 35 mm film cassette, an E2 extension tube, and a Skylab automatic flash unit. A detailed description of the hardware is contained in reference 4.

Since the 300 mm f/4.5 lens was added for damage assessment after the Saturn Workshop launch, it is not contained in the above reference. This lens is virtually an off the shelf lens with the only modification being the removal of the lens hood. The lens is 20.7 centimeters by 8.1 centimeters and weighs 1 kilogram. It has a field of view of 0.079 radian by 0.119 radian. This lens provided the details necessary for postflight assessment of the damage to the Orbital Workshop and high resolution ground photography of targets of interest.

TABLE A-I.- 16 mm DATA ACQUISITION CAMERA SYSTEM

Item	Quantity
Data acquisition camera (Saturn Workshop)	10
Data acquisition camera (First visit)	1
Data acquisition magazine (Saturn Workshop)	12
Data acquisition magazine (First visit)	3
122 meter canister	90
122 meter film drive	8
5 mm lens	4
10 mm lens	4
18 mm lens (Saturn Workshop)	2
18 mm lens (First visit)	1
25 mm lens	1
75 mm lens (Saturn Workshop)	2
75 mm lens (First visit)	1
100 mm lens	2
Remote control system	6
Right angle mirror (Saturn Workshop)	2
Right angle mirror (First visit)	1
Ring Sight	3
Command module power cable (First visit)	1
Orbital Workshop/Multiple Docking Adapter power cable (Saturn Workshop)	6
Universal mount	13
Universal mount (Extravehicular Activity)	2
Extravehicular activity bracket	1
Power pack (First visit)	1
Data acquisition camera shutter cover	1
Transporter tool	1
Film profile tool	2
Spare fuse (Saturn Workshop)	12
Spare fuse (First visit)	1

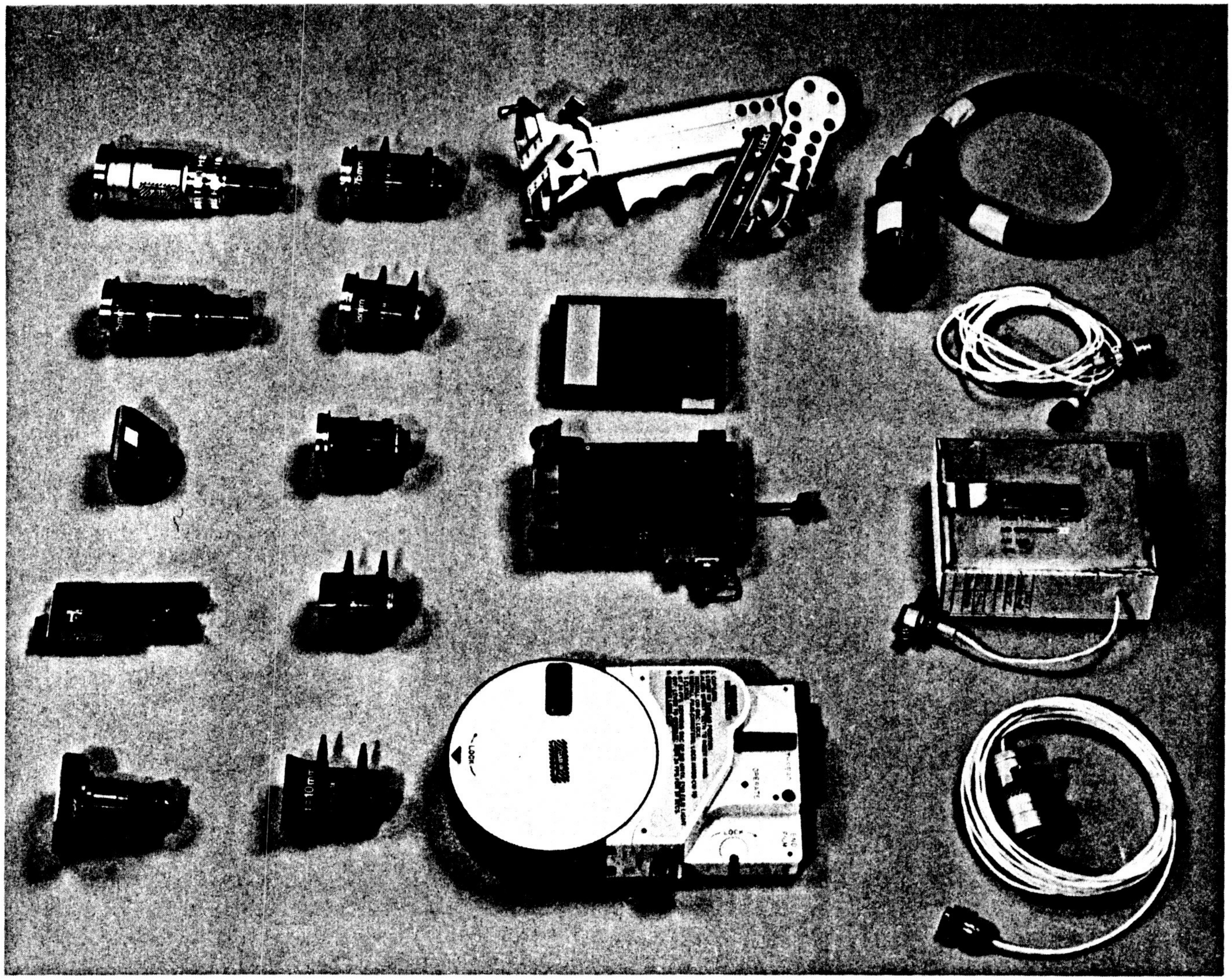


Figure A-1.- Data acquisition camera (16 mm) system.

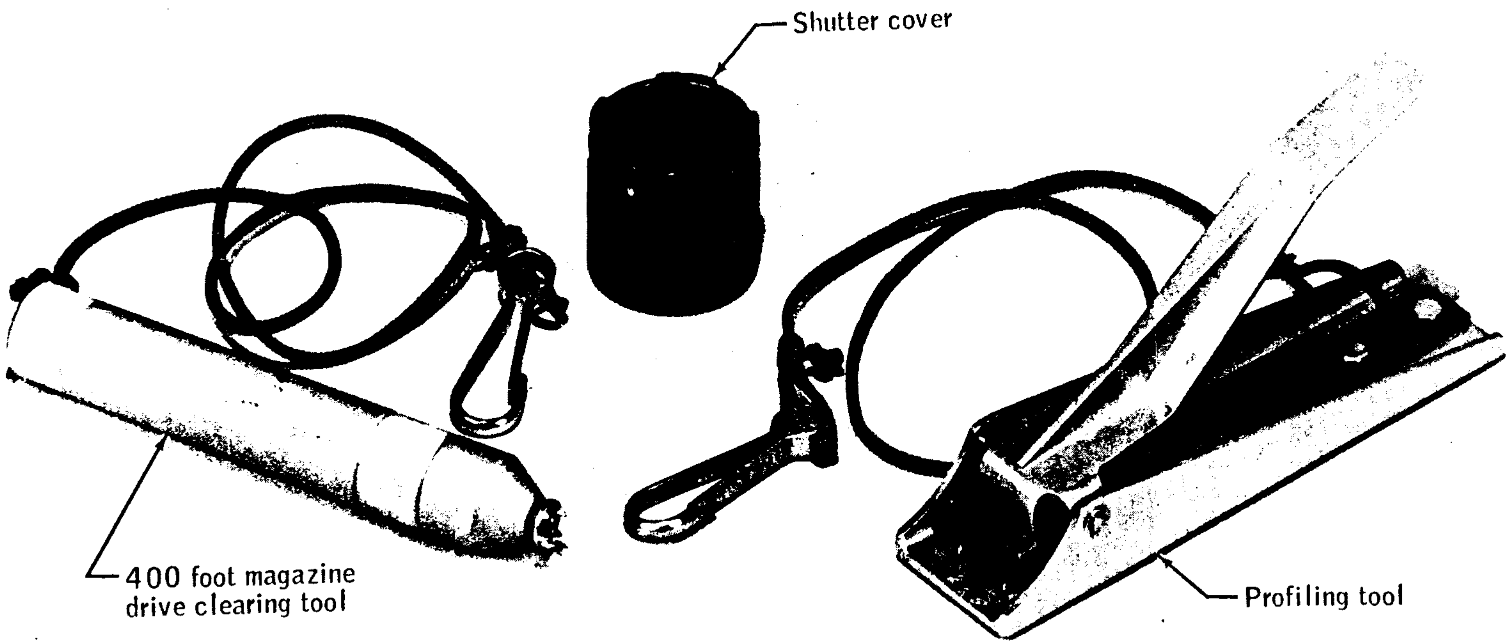


Figure A-2.- Data acquisition camera film loading tools.

Figure A-3.- 35 mm camera.

A.3 70 mm Data Camera System

The Orbital Workshop complement of 70 mm equipment consists of one data (reseau) camera with 100 mm lens and reseau protective cover attached, and two 70 mm film magazines (fig. A-4). The camera is stowed in locker F523 and the film magazines in the Orbital Workshop film vault. Batteries for the Orbital Workshop camera system are launched in the command module.

The command module complement of equipment includes one data camera with 80 mm lens and film magazine attached. Batteries are installed in the command module camera and two additional batteries are carried separately for the Orbital Workshop camera. An additional film magazine was carried on the first visit for damage assessment.

A complete description of the components of the data camera system may be found in reference 4.

A.4 127 mm Earth Terrain Camera

The earth terrain camera is a modified version of the lunar topographic camera carried on the Apollo 13 and 14 missions. The body is an extensively modified KA-74 reconnaissance camera body with a focal plane shutter and vacuum film flattening. The lens has a focal length of 460 mm, a fixed aperture of f/4, color correction, and maximum radial distortion of 10 μm. Forward image motion compensation is provided by rocking the entire camera in its mount during the exposure.

The frame format is 115 mm by 115 mm so that, at the Skylab mission altitude, the format covers an area of 109 kilometers by 109 kilometers. Characteristics of the camera can be summarized as follows:

Lens - 460 mm focal length, f/4 fixed aperture, color corrected

Lens distortion - radial, ±10 μm; tangential, <5 μm.

Shutter - focal plane, bidirectional; 1/100, 1/140, 1/200 sec

Forward motion compensation - by rocking camera, 0 to 25 mrad/sec

Film - 125 mm , 0.05 mm base; 400 frames/roll

Format - 115 by 115 mm

Framing rate - 0 to 25 frames/min

Overlap - 60 percent standard; 0 to 80 percent available

Ground coverage at nadir - 109 by 109 kilometers

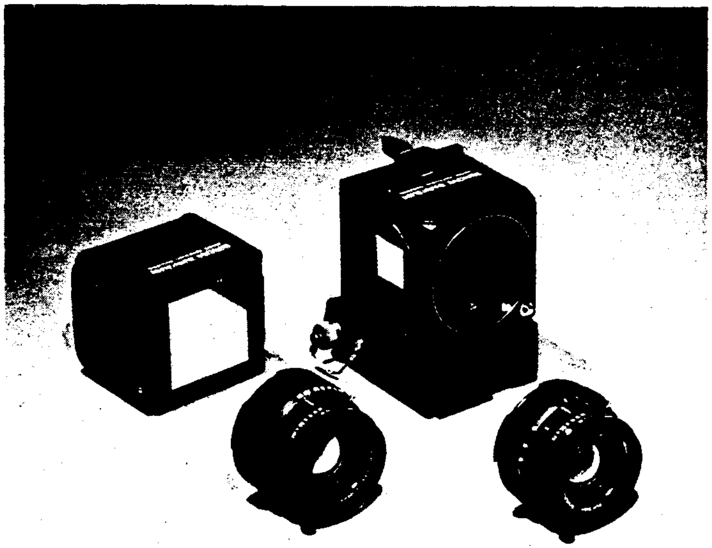
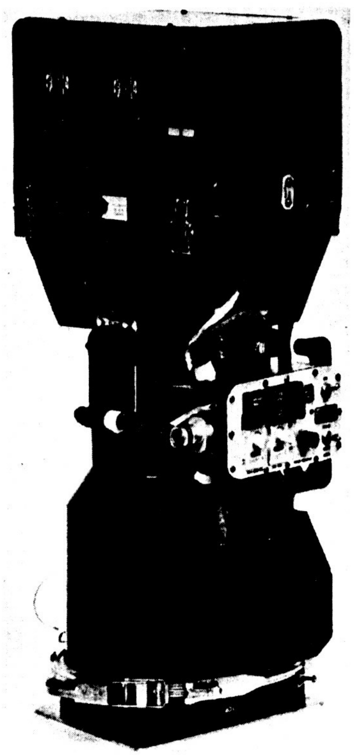
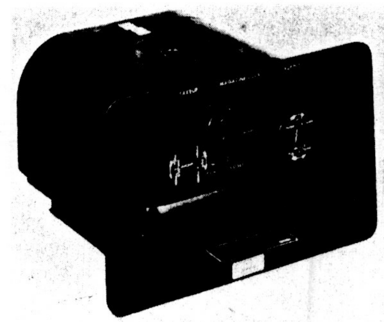


Figure A-4.- 70 mm camera system.

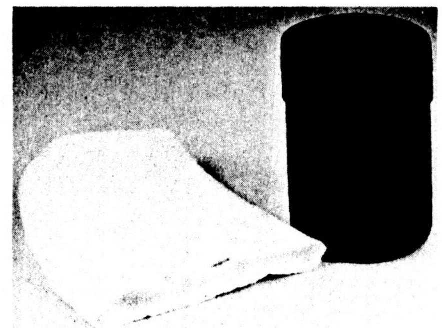
Additional equipment supplied for use with the earth terrain camera are as follows: window, lens protective cover, five filters, six spare desiccants, a magazine cavity cover, a spare magazine, and four film canisters. See figure A-5 for a layout of this equipment.



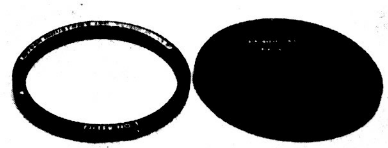
Camera



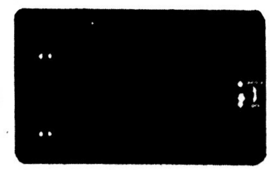
Spare magazine



Film canister and bag (4) each for Orbital Workshop and (6) each for the first and second visits.

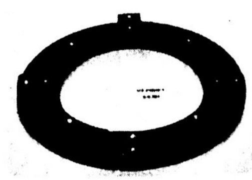


Filter (5) each



Cavity cover

Desiccant (6) each



Lens protective cover

Window with protective covers

Figure A-5.- Earth terrain camera system.

APPENDIX B - SPACECRAFT HISTORY

The history of command and service module (CSM-116) operations at the manufacturer's facility, Downey, California, is shown in figure B-1, and the operations at Kennedy Space Center, Florida, is shown in figure B-2.

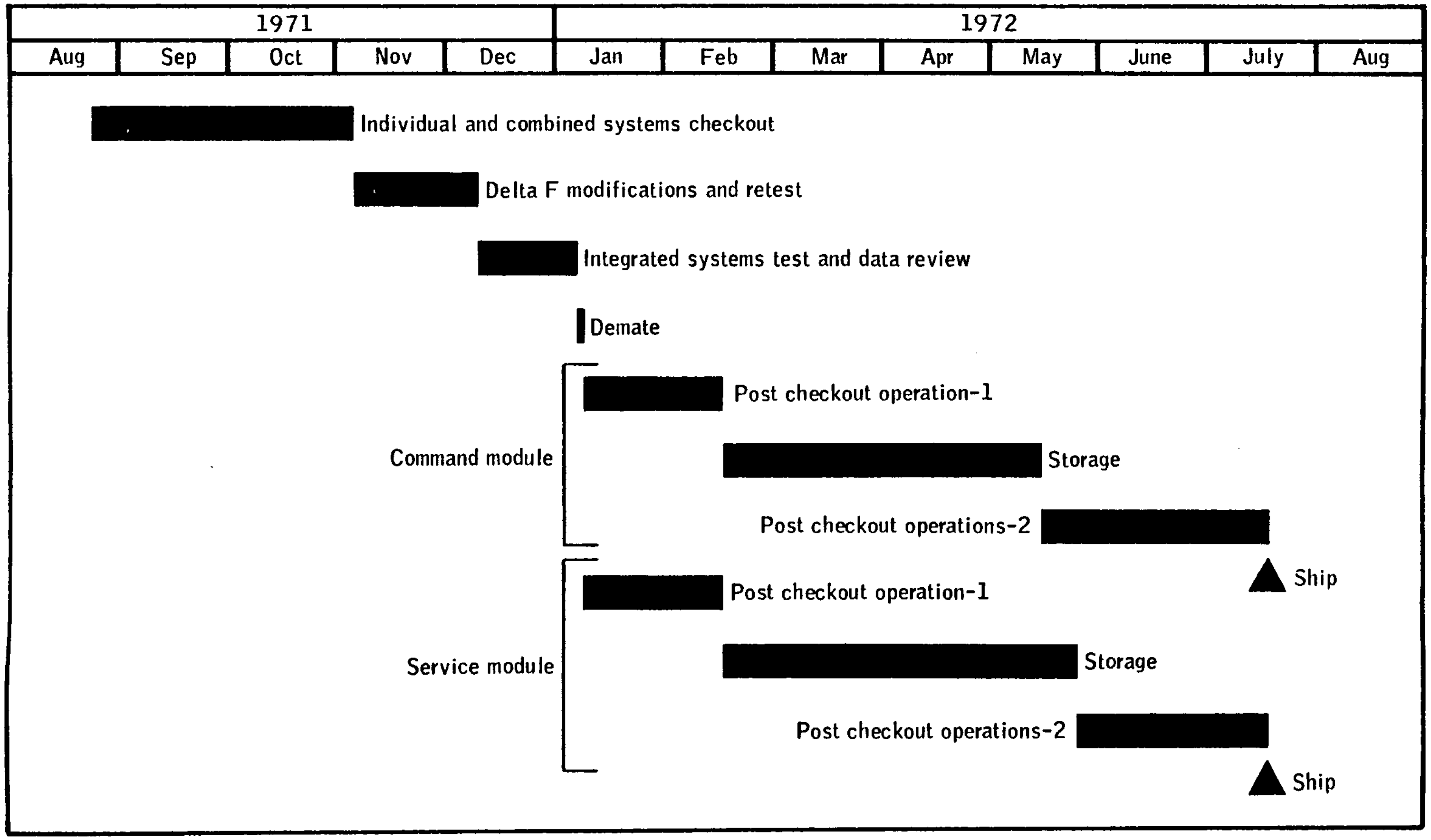


Figure B-1.- First visit command and service module (116) history at Contractor facility.

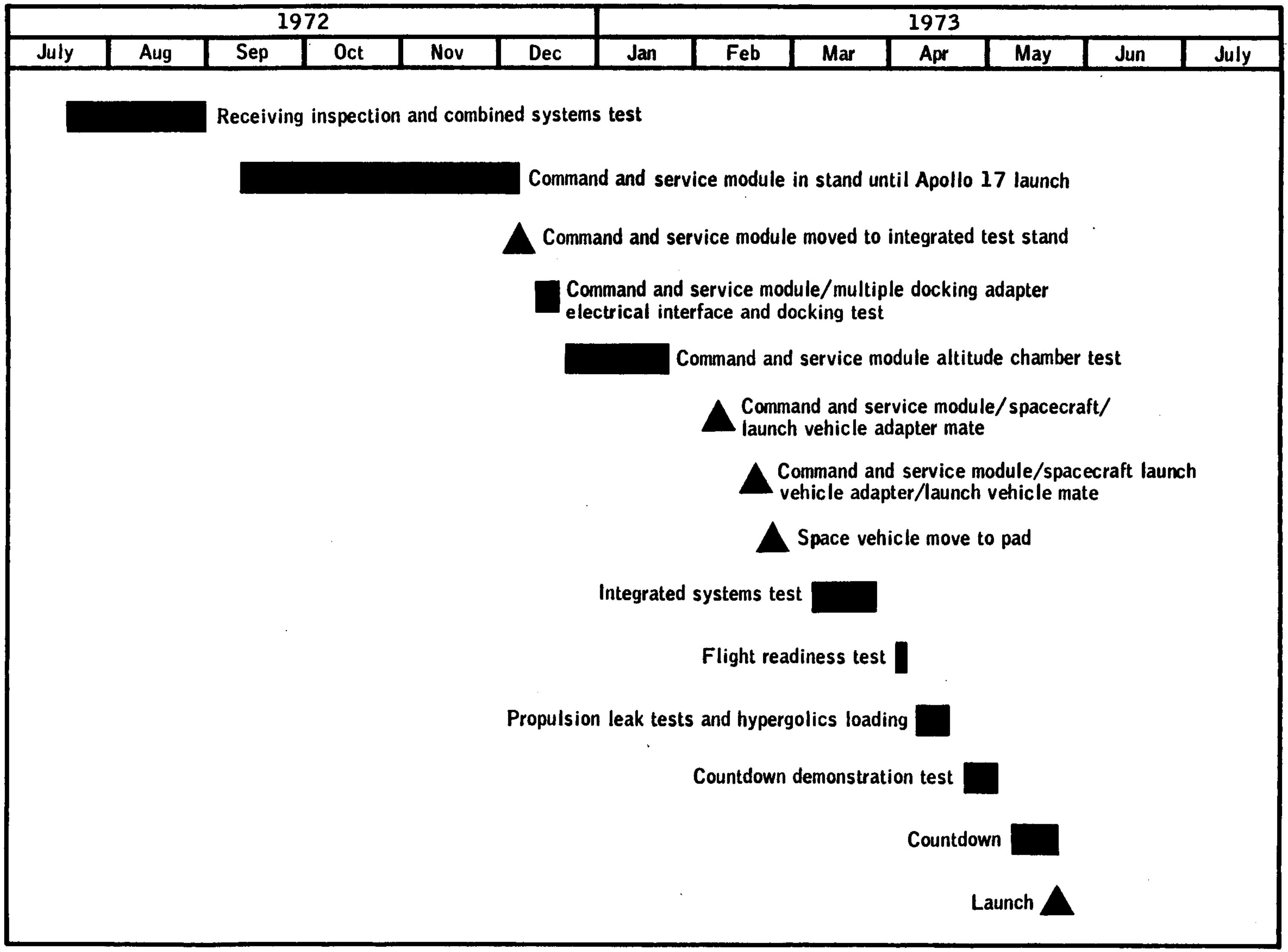


Figure B-2.- First visit command and service module (116) history at Kennedy Space Center.

APPENDIX C - POSTFLIGHT TESTING

Postflight testing and inspection of the command module and crew equipment for evaluation of the inflight performance and investigation of flight problems were conducted at the contractor's and vendor's facilities and at the Johnson Space Center in accordance with approved Spacecraft Hardware Utilization Requests (SHUR's). The tests performed as a result of inflight problems are described in table C-I and discussed in the appropriate systems performance section of this report. Tests being conducted for other purposes in accordance with other SHUR's and the basic contract are not included.

TABLE C-I.- POSTFLIGHT TESTING SUMMARY

SHUR no.	Purpose	Test performed	Results
		Environmental Control	
116007	Determine cause of secondary evaporator temperature reading low.	Remove equipment and perform teardown failure analysis.	Problem caused by shorted bias in signal conditioner amplifier.
116010 116014	Investigate cause of suit circuit pressure cycling.	Inspect and leak test suits, suit hoses, and suit circuit components.	Problem could not be duplicated or cause determined.
		Communications	
116011	Determine cause of unscheduled turn-off of command and service module FM transmitter during uplink commands.	Operate updata link in command module and remove equipment for bench tests and failure analysis.	Anomaly duplicated. Shorted diode caused FM transmitter to switch off.
116009	Determine cause for TV camera failure.	Perform failure analysis.	Internal short caused by contamination particle in video synchronization hybrid circuit.
116008	Investigate spotted images seen on television transmissions.	Perform inspection.	Contamination on camera faceplate and back side of color wheel.
		Electrical	
116017	Determine if command module circuitry caused the activation of a secondary radiator heater with the switch in the OFF position.	Test integrity and isolation of the secondary radiator heater control circuit.	Circuitry normal.
		Reaction Control	
116507	Determine cause for system 1 fuel tank bladder leak.	Remove tank and perform failure analysis.	A U-shaped hole in bladder of approximately 3/8 inch diameter. Cause of hole not determined.
		Guidance and Control	
116015	Investigate erroneous trunnion angle indications in guidance and control system optics.	Remove equipment and perform failure analysis.	Failure analysis in progress.
		Crew Equipment	
116018	Determine why 70-mm film magazine frame counter stopped counting.	Perform inspection	Low and rounded gear teeth on the counter drive gear.

APPENDIX D - MASS PROPERTIES

Mass properties for the Saturn Workshop launch and the first visit are summarized in table D-I. These data represent the conditions as determined from analyses of expendable loadings and usage during the flight. Variations in the command and service module and Saturn Workshop mass properties are determined for each significant mission phase from lift-off through landing. Expendables usage are based on reported real-time data. The weights and center-of-gravity of the individual modules were measured prior to flight and inertia values were calculated. All changes incorporated after the actual weighing were monitored, and the mass properties were updated.

TABLE D-I.- MASS PROPERTIES

Event	Weight, kg	Center of gravity, cm			Moment of inertia, kg m^2			Product of inertia, kg m^2		
		X	Y	Z	I_{XX}	I_{YY}	I_{ZZ}	P_{XY}	P_{XZ}	P_{YZ}
Saturn Workshop Launch and Deployment										
Lift off	89 095.5	8361.9	-4.3	7.9	548 296	6 008 545	6 042 229	-13 422	4452	17 633
Saturn Workshop in orbit[a]	75 687.3	8256.5	0.7	12.1	426 704	4 634 993	4 666 736	-55 286	-4208	13 680
Apollo Telescope Mount deployed	75 582.6	8182.4	0.7	-72.3	735 752	3 768 734	3 491 426	-56 858	-522 582	12 857
Apollo Telescope Mount solar arrays deployed	75 424.3	8184.2	0.4	-75.3	818 257	3 841 937	3 601 367	-59 872	-540 073	13 973
Control moment gyro spin-up complete	75 199.7	8185.9	0.4	-75.6	818 091	3 832 767	3 592 331	-59 876	-539 046	13 973
Rendezvous complete	74 782.4	-816.7	-0.4	76.0	815 653	3 808 510	3 568 336	59 806	538 339	13 787
First Visit										
Lift off	19 982	2550.9	5.8	5.1	38 502	530 809	531 673	-3283	1090	-1625
Initial orbit achieved	14 023	2448.1	7.5	6.5	23 908	71 074	72 079	-1591	939	-1628
Coelliptic orbit	13 516	2456.3	7.0	6.4	23 060	67 983	68 419	-1350	863	-1656
Rendezvous complete	13 386	2475.5	6.5	7.2	22 827	67 598	68 047	-1282	774	-1582
Command and service module post-flyaround no. 1	13 277	2458.2	5.9	8.1	22 633	67 370	67 898	-1214	667	1500
Command and service module at soft dock	13 276	629.1	0.3	-10.0	22 633	66 132	69 135	1381	-146	265
Saturn Workshop at soft dock	74 777	-816.7	-0.4	76.0	815 638	3 807 684	3 567 514	59 806	538 288	13 787
Orbital assembly configuration at soft dock	88 054	-598.7	-0.3	63.0	846 611	6 238 751	5 993 245	62 301	397 951	13 987
Command and service module post-flyaround no. 2	13 116	2459.5	5.2	9.3	22 349	67 038	67 668	-1129	540	-1384
Saturn Workshop at hard dock	74 773	-816.6	-0.4	76.0	815 622	3 806 862	3 566 693	59 805	538 236	13 787
Orbital assembly configuration at hard dock	87 805	-602.3	-0.6	63.1	846 208	6 194 715	5 948 883	58 658	398 697	14 050
Command and service module transfers complete	87 608	-612.0	-2.6	63.8	849 410	6 135 855	5 892 369	70 711	399 578	15 341
Solar array system no. 1 deployed at 90°	87 467	-609.9	-8.6	63.8	925 176	6 077 562	5 910 543	86 733	392 937	28 541
Command and service module reaction control system trim maneuver	87 246	-607.7	-8.2	64.4	921 253	6 079 120	5 914 593	86 288	390 571	27 814
Command and service module pre-separation from Saturn Workshop	87 179	-604.9	-8.3	63.9	919 954	6 113 711	5 948 431	87 313	390 152	27 386
Saturn Workshop remaining in orbit	74 428	-815.8	-9.8	76.5	892 442	3 773 920	3 614 293	70 128	526 226	28 389
Command and service module post-flyaround no. 3	12 627	2461.8	5.1	9.7	21 344	65 269	66 357	-1247	729	-993
Command and service module at CM/SM separation	11 932	2472.8	4.0	10.0	20 375	59 235	59 519	-851	646	-1071
Command module at entry interface	5894	2638.8	-0.2	16.0	8014	7031	6284	67	-558	-12
Command module at drogue mortar firing	5661	2635.0	-0.2	15.8	7823	6605	5881	69	-528	-8
Command module at landing	5422	2629.2	-0.3	16.2	7711	6118	5390	66	-496	-6

[a]Payload shroud jettisoned solar array system no. 2 missing, and micrometeroid shield removed except for 31.8 kilograms of debris.

APPENDIX E - CONVERSION DATA

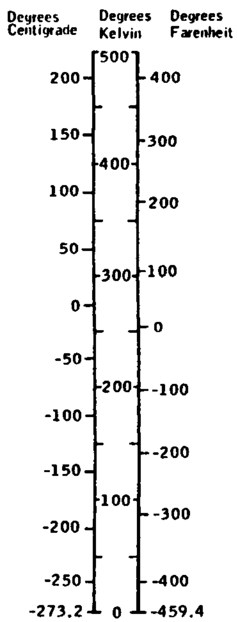
The values shown in this report conform to SI standards. Relationship to conventional units of measurement is shown in figure E-1.

1973 Date		Day of year	Visit Day
May	14	134	
	15	135	
	16	136	
	17	137	
	18	138	
	19	139	
	20	140	
	21	141	
	22	142	
	23	143	
	24	144	
	25	145	1
	26	146	2
	27	147	3
	28	148	4
	29	149	5
	30	150	6
	31	151	7
June	1	152	8
	2	153	9
	3	154	10
	4	155	11
	5	156	12
	6	157	13
	7	158	14
	8	159	15
	9	160	16
	10	161	17
	11	162	18
	12	163	19
	13	164	20
	14	165	21
	15	166	22
	16	167	23
	17	168	24
	18	169	25
	19	170	26
	20	171	27
	21	172	28
	22	173	29

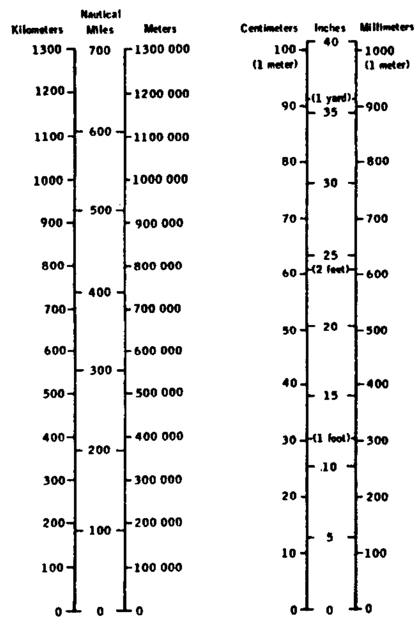
(a) Date conversion

Figure E-1.- Conversion data.

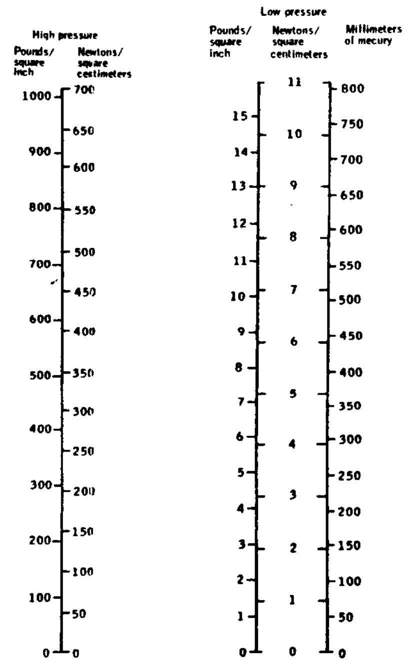
E-2 A B



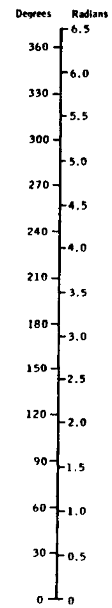
(b) Temperature conversion



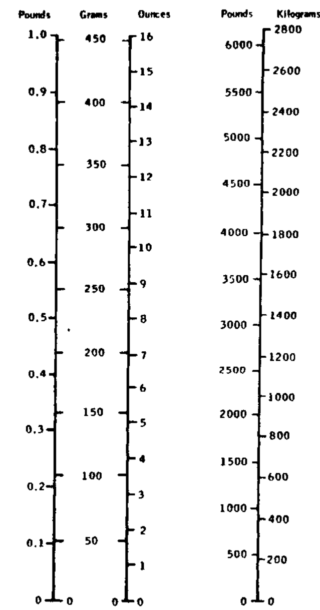
(c) Linear measurement conversion



(d) Pressure conversion



(e) Angular conversion



(f) Mass conversion

APPENDIX F - GLOSSARY

Acetylcholinesterase	An enzyme that hydrolyzes acetylcholine thereby regulating nerve transmission.
Aerotitis media	Inflammation of the middle ear caused by pressure differences between the middle ear cavity and the surrounding atmosphere.
Aldosterone	A steroid hormone extracted from the adrenal cortex that is very active in regulating the salt and water balance in the body.
Antidiuresis	Suppressing the secretion of urine.
Atrophy	Wasting away or diminution in size.
Bioassay	The determination of the active power of a drug sample by noting its effects on animals or compared with the effect of a standard preparation.
Corotid	Principal artery of the neck.
Cortisol	A carbohydrate regulating hormone isolated from adrenal cortex.
Diastolic pressure	Arterial pressure during heart relaxation.
Diunesis	Increased secretion of urine.
Electrolytes	Term used in clinical medicine to denote the ions in body fluids.
Endocrinological	Pertaining to secretions from organs whose actions affect all or part of another organ.
Erythropoiesis	Production of red blood corpuscles.
Fixative	An agent employed in the preparation of a histologic or pathologic specimen for the purpose of maintaining the existing form and structure of all its constituent elements.
Flaccidity	Soft and limp.
Glutathione	A co-enzyme of gyoxalase and acts as a respiratory carrier of oxygen.

Hematocrit	Percent of red blood cells to volume of whole bood after centrifugation.
Hemoglobin	The oxygen-carrying red pigment of the red blood corpuscles.
Hemolytic	Destruction of red blood cells with separation of hemoglobin from the cells.
Humoral-cellular	Referring to the two broad categories of immunity: noncellular and cellular.
Immunoglobulins	Immune proteins.
Lymphopenia	A decrease in the proportion of white blood corpuscles.
Lysozyme	An antibacterial enzyme that is present in saliva and tears.
Malaise	A vague feeling of body discomfort.
Methemoglobin	A modified form of hemoglobin found in the blood.
Muscle tonus	Normal muscle tension which aids in the maintenance of posture and in the return of blood to the heart.
Norepinephrine	An organic nitrogen compound present in the adrenal glands which raises blood pressure.
Oculogyral illusion	Apparent lateral motion of a fixed visual target induced by specific rotational acceleration.
Orthostatic	Pertaining to or caused by standing erect.
Protease	An enzyme or ferment that digests proteins.
Rad	A unit of absorbed dose of ionizing radiation equal to an energy of 0.01 joules/kilogram of irradiated material.
Rem	A radiation biological effectiveness factor of biological injury to human tissue for any dose of ionized radiation equivalent to one roentgen of X-ray or gamma ray.

Renal	Functions of the kidney.
Serum	The clear, yellowish fluid which separates from the clot when blood coagulates.
South Atlantic Anomoly	A pocket of trapped protons and electrons in the Van Allen Belt located over a large portion of South America, the South Atlantic and the Southern tip of Africa.
Staphylococcus aureus	A spherical bacterium vegetable organism found characterized by a tendency for daughter cells to remain attached following cell devision. Found in air and milk and produces a lemon yellow pigment.
Stereophotogrammetry	Photogrammetry involved in the use of stereoscopic photographs.
Tendon reflexes	Muscle contraction resulting from a blow on its connective cord.

REFERENCES

1. NASA Headquarters: Mission Operation Report, Skylab Supplement. OSMF Report No. M-960-73. March 1, 1973.

2. Johnson Space Center: Scientific Data Analysis and Reporting Plan - MSC Skylab Experiments. MSC-03022. July 14, 1972.

3. Johnson Space Center: EREP Sensor Evaluation Report. MSC-05528.

4. Johnson Space Center: Handbook of Pilot Operational Equipment for Manned Space Flight. MSC-07210. June 16, 1972.

5. Anon.: Manual of Physical Properties of Kodak Clerical and Special Sensitized Materials, Section 12. Kodak publication No. M-111, Rev. 10-63. Eastman Kodak Company, Rochester, N.Y., Dept. GS.